# WiDS Initiative
# Barriers Literature Review

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# 1) Barriers related to Discrimination, Hostile Environments, Self-Identity, and Beliefs

***Hostile academic and career environments where women face direct discrimination and biases, as well as microaggressions, may make students and professionals feel as if they do not belong in data science and AI. This may contribute to a lack of self-confidence and self-efficacy, Imposter Phenomenon, stereotype threat, or lack of self-identity with data science or AI careers. This may cause women to not apply to graduate programs, to not enroll in programs, or to drop out of graduate studies.***

## Discrimination

Rankin, Yolanda A., Jakita O. Thomas, and Sheena Erete. "Real Talk: Saturated Sites of Violence in CS Education." In *Proceedings of the 52nd ACM Technical Symposium on Computer Science Education*, 802–808. SIGCSE '21. Virtual Event, USA: Association for Computing Machinery, 2021. https://doi.org/10.1145/3408877.3432432.

> This study included interviews of 18 women in computer science at various points in their career trajectories. This conference paper finds that there are three areas where black women experience the most discrimination in pursuing careers in computer science, which are traditional K-12 classrooms; 2. predominantly White institutions; and 3. internships as supplementary learning experiences.

True-Funk, Arielle, Cristina Poleacovschi, Gloria Jones-Johnson, Scott Feinstein, Kalynda Smith, and Stephanie Luster-Teasley. "Intersectional Engineers: Diversity of Gender and Race Microaggressions and Their Effects in Engineering Education." *Journal of Management in Engineering* 37, no. 3 (May 1, 2021): 04021002. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000889.

> This study interviewed students at multiple institutions to understand the impacts of their experiences of microaggressions based on their intersectionality. Using an intersectional perspective, the study found that the effects of microaggressions on undergraduate engineering students reduced self-esteem, led to racial/gender isolation, and contributed to stereotype threat. Latinas and Latinos were most likely to report reduced self-esteem. Asian women and Latino men reported racial/gender isolation more than other intersectional identities. However, Asian women felt isolated both by race and gender whereas Latino men felt only isolated by race. Asian women and Asian men reported stereotype threat more commonly than other intersectional identities. The study also found an empowered sense of self for African American women and African American men. The study states that "these intersectional identities were able to locate the negative experiences with the aggressors rather than internalizing and accepting fault."

## Climates and settings

See also Bayer 2012

Dresden, Brooke E., Alexander Y. Dresden, and Robert D. Ridge. "The Boys Club: Engineering a More Positive Environment for Women in Male-Dominated Majors." *Social Sciences* 7, no. 2 (February 2018): 17. https://doi.org/10.3390/socsci7020017.

> This is a lab experiment to understand how men react to female leaders if they perceive their masculinity is threatened in male-dominated majors. They had 142 male participants in either male dominated or gender neutral majors. They were told that the female leaders were either 1)( high-threat) selected because they scored higher in the traits of assertiveness, capability, independence, and rationality or 2) (low-threat) randomly assigned. The study found that for men who had self-reported as "masculine" who experienced a high gender threat and came from a male-dominated major increased their behavioral aggression, while their perceptions of a female leaders' effectiveness decreased. This only occurred for this sub-group.

Kreth, Quintin, Mary Eve Spirou, Sarabeth Budenstein, and Julia Melkers. "How Prior Experience and Self-Efficacy Shape Graduate Student Perceptions of an Online Learning Environment in Computing." *Computer Science Education* 29, no. 4 (October 2, 2019): 357–81. https://doi.org/10.1080/08993408.2019.1601459.

> This article focuses on the online learning environment at the graduate level. They find that women (particularly US citizens) and older students have more negative perceptions of the online learning environment in computing. However, they find that pre-existing learning self-efficacy can mitigate this effect.

## Self-efficacy/ Self-confidence

Isaac, Carol, Anna Kaatz, Barbara Lee, and Molly Carnes. "An Educational Intervention Designed to Increase Women's Leadership Self-Efficacy." *CBE—Life Sciences Education* 11, no. 3 (September 1, 2012): 307–22. https://doi.org/10.1187/cbe.12-02-0022.

> This is a case study regarding a 16-week course designed to increase women in STEMM's leadership self-efficacy. This course was for early career graduate students, postdocs, and faculty. They identified five stages of change and an accompanying 10 processes of change for participants of the course. They argue that the overall quantitative and qualitative results supported the effectiveness of the course in improving women's leadership self-efficacy through bias literacy, invoking efficacy-building experiences (e.g., presentations and discussions, meeting role models; Brown, 1999), and incorporating opportunities for deep and transformative learning (e.g., journaling, case studies). **This article is an example of a single university's promising practice.**

Stewart, John, Rachel Henderson, Lynnette Michaluk, Jessica Deshler, Edgar Fuller, and Karen Rambo-Hernandez. "Using the Social Cognitive Theory Framework to Chart Gender Differences in the Developmental Trajectory of STEM Self-Efficacy in Science and Engineering Students." *Journal of Science Education and Technology* 29, no. 6 (December 1, 2020): 758–73. https://doi.org/10.1007/s10956-020-09853-5.

> This study surveyed 1,896 undergraduate students at one university. They found that students' self-efficacy beliefs differed by academic STEM domain. There were also gender differences, but they differed by STEM domain as well.

## Self-identity

See also Wolniak, et al. 2020

Buse, Kathleen, Diana Bilimoria, and Sheri Perelli. "Why They Stay: Women Persisting in US Engineering Careers." *Career Development International* 18, no. 2 (May 17, 2013): 139–54. https://doi.org/10.1108/CDI-11-2012-0108.

> This study is based on qualitative interviews with 31 women engineers, ten of whom had left an engineering career and 21 persisting for an average of 21 years. The participants in the study had undergraduate degrees in science (one) and engineering (30), broken into the following subdisciplines: biomedical (one), chemical (12), civil (four), industrial (four), electrical (two) material/metallurgical (two), or mechanical (five). More than half of the women had Master's degrees (2 nine in engineering, seven MBA's, one masters of education, and one masters in counseling). Three had doctorates (two in engineering, one in management) and two others were in the process of obtaining doctorates. The persistent women engineers had never chosen to leave an engineering career and were either still working as an engineer or were in a management role. The remaining ten women had chosen to leave an engineering or technical management career prior to the time of the study after an average of 12 years of experience. Six had exited for non-engineering careers; the four others to be stay-at-home mothers. Employer industries included: chemical, pharmaceutical, electronics, oil, food, metals, fluid technology, communications, electronics, entertainment, consumer products, automobile manufacturers, automobile suppliers, and consulting. The individual factors related to women's persistence included self-efficacy, identity as an engineer, adaptability to difficult workplaces where they experienced discrimination and/or harassment, and engagement in work where they have reciprocal engagement with others, including collaboration and support, counsel, and advice, match of interests and continuous learning opportunities, and their family situation, as those that persisted were less likely to be married and have less children or not have children than those who opted out of the profession.

Crossley, Alison Dahl. "Clash of Independence and Interdependence Creates Conflict, Fuels Gender Inequality." The Clayman Institute for Gender Research, March 20, 2018. https://gender.stanford.edu/news-publications/gender-news/clash-independence-and-interdependence-creates-conflict-fuels-gender.

> This article discusses Hazel Rose Markus' psychology theories and studies in interdependence and independence. Markus defines interdependence as the self valuing

relationships and those around them, whereas independence as the self valuing themself. The article states society teaches boys from an early age to be more independent, but teaches girls to be more interdependent. People of color and working class people were also found to be more interdependent, meaning having privilege means being more independent. The article advocates for both men and women to find a balance between the two selves.

Sax, Linda J., M. Allison Kanny, Tiffani A. Riggers-Piehl, Hannah Whang, and Laura N. Paulson. "'But I'm Not Good at Math': The Changing Salience of Mathematical Self-Concept in Shaping Women's and Men's STEM Aspirations." *Research in Higher Education* 56, no. 8 (2015): 813–42. https://www.jstor.org/stable/24572043.

This study examines the idea that female students who exhibit lower mathematical self-concept compared to their matched-ability male peers are less likely to pursue a STEM major due to the perception that these courses of study require high-level mathematical ability across different STEM fields. Additionally, female students who do pursue STEM majors, more so than their male counterparts, experience a number of factors that lead to the decline of their self-perceived math ability during college. In comparing five STEM subfields: biological sciences, computer science, engineering, mathematics/statistics, and physical sciences, they found for both women and men, the highest math self-ratings were observed among students in math/statistics, followed by engineering, physical sciences, computer science, and biological sciences. They also found a gender gap for all of the subfields, which has been persistent over time, except for in engineering, where it did not exist until the mid-1980s. Additionally, for women, the salience of math self-concept has grown in the prediction of selecting majors in math/statistics, but has weakened over time in explaining women's decision to major in the remaining four STEM subfields.

## Imposter Phenomenon

Lindemann, Danielle, Dana Britton, and Elaine Zundl. "'I Don't Know Why They Make It So Hard Here': Institutional Factors and Undergraduate Women's STEM Participation." *International Journal of Gender, Science and Technology* 8, no. 2 (May 25, 2016): 221–41. http://genderandset.open.ac.uk/index.php/genderandset/article/view/435.

This study focused on women in STEM at a Women's Residential College. They found the women repeatedly drew connections between their feelings of inadequacy—feelings at the core of "imposter Phenomenon" and "stereotype threat"—and the size of the classes at WRC. They also found a culture of STEM courses designed to "weed people out" and to "make you fail". These were particularly true for URM and those who did not have parents with STEM backgrounds. Qualitative evidence supported a connection between STEM persistence and participation in programs for women in STEM as a guard against "imposter Phenomenon."

McGee, Ebony O., Portia K. Botchway, Dara E. Naphan-Kingery, Amanda J. Brockman, Stacey Houston II, and Devin T. White. "Racism Camouflaged as Impostorism and the Impact on Black STEM Doctoral

Students." *Race Ethnicity and Education* 0, no. 0 (May 13, 2021): 1–21. https://doi.org/10.1080/13613324.2021.1924137.

> This paper argues that some Black students are unable to fully internalize their success within racially hostile engineering and computing environments. They may question their academic ability as racialized beings and view themselves as imposters. The students described encountering explicit and implicit messages that positioned them as imposters during their academic career, which they indicated initially made them feel isolated, leading them to question their abilities.

Tao, Karen W., and Alberta M. Gloria. "Should I Stay or Should I Go? The Role of Impostorism in STEM Persistence." *Psychology of Women Quarterly* 43, no. 2 (June 1, 2019): 151–64. https://doi.org/10.1177/0361684318802333.

> This study surveyed 224 self-identified women doctoral students enrolled in a STEM-related graduate program and attending a large Midwestern university. They found that while STEM doctoral women maintain fairly high levels of impostorism, enhanced self-efficacy and a conducive doctoral environment can counteract those beliefs and support persistence in STEM graduate programs. They found that the degree of confidence and motivation to persist improves with opportunities to engage in meaningful research with like-minded others, including peers, mentors, and experts, and experiencing early and ongoing success in field-specific tasks. Imposterism increased in programs with less women.

### Beliefs and perceptions

Jackson, Sarah M., Amy L. Hillard, and Tamera R. Schneider. "Using Implicit Bias Training to Improve Attitudes toward Women in STEM." *Social Psychology of Education* 17, no. 3 (2014): 419–38. https://doi.org/10.1007/s11218-014-9259-5.lot

> This study examines the impacts of gender diversity trainings on bias. The article states that while there are a lot of diversity training programs, there has been little research on the best approaches. This study assessed changes in explicit attitudes and implicit associations of 251 STEM faculty at four universities after exposure to diversity training. The study did not find a change for women, as women's implicit associations started off and remained positive. For men they found that after diversity training, men had a significant increase in personal, positive implicit associations toward women in STEM. They did not find correlations between explicit and implicit findings as both groups had high positive explicit responses indicating possible compliance with socially desirable responses. **This possibly provides an intervention worth examining further.**

## 2) Barriers Related to Resources, Costs, and Time Considerations

***Women who do see the benefit to graduate study or anticipate being able to complete a graduate program are less likely to be willing to incur the costs of graduate programs, which include academic, resource, and social costs.***

See also Jackson, et al. 2008; Maheshwari, et al. 2009

Mosyjowski, Erika A., Shanna R. Daly, Diane L. Peters, Steven J. Skerlos, and Adam B. Baker. "Engineering PhD Returners and Direct-Pathway Students: Comparing Expectancy, Value, and Cost." *Journal of Engineering Education* 106, no. 4 (2017): 639–76. https://doi.org/https://doi.org/10.1002/jee.20182.

> This article surveyed 179 returners and 297 direct-pathway domestic engineering doctoral students to better understand why people return to school to pursue engineering PhDs after significant work experience. They found no significant differences between expectancies of returners and direct-pathway students, once enrolled, in their anticipated ability to attain a PhD, nor were there differences in the perceived value of the doctoral degree. However, they did find that returners reported a lower expectancy of success prior to beginning their doctoral studies, as well as significantly higher perceived financial, academic, and balance costs than direct-pathway students during their degree programs. They also found that gender and race were also associated with significant differences in participants' reported level of cost associated with pursuing a PhD in engineering. Specifically, they found gender-based differences in students' perceived levels of both balance costs and academic costs, which included challenges related to adapting to the graduate school environment and culture, finding peers to work with, and doubting their abilities.

## 3) Barriers Related to Pedagogy, Curricula, Academic Activities, and Classroom Experiences

***Women's experiences in undergraduate and graduate classrooms do not encourage them to pursue or remain in graduate programs in data science or AI. This may include not taking undergraduate courses or completing undergraduate courses which will prepare them for graduate school.***

Bennett, Jill E., and Denise Sekaquaptewa. "Setting an Egalitarian Social Norm in the Classroom: Improving Attitudes towards Diversity among Male Engineering Students." *Social Psychology of Education* 17, no. 2 (2014): 343–55. https://doi.org/10.1007/s11218-014-9253-y.

> This study focused on the role of perceived social norms in an engineering classroom of 226 students in promoting egalitarian behavior and increasing positive attitudes toward diversity in engineering. Students received an experimental message regarding egalitarian social norms from the dean in two of four ENGIN 100/151 sections near the beginning of the term. The message was delivered by a credible source "a senior level White male faculty member whose departmental status and years of experience were noted in his introduction." The message included descriptive social norms "Students here understand the value of learning alongside students who are different from themselves" as well as injunctive norms "Once a student made a racist comment during lecture and the rest of the class groaned; it was hard for that student to find a study partner after that". Suggestions were then given to students on how to avoid biased behaviors. Students were then given an environmental cue to trigger the normative behavior through a reminder message as well as a physical reminder later in the term. White men in the experimental condition reported more positive attitudes towards diversity in engineering compared to White men in the control condition, changing their attitudes to levels comparable to racial/ethnic minority men. In addition, results demonstrated that male students who had received the experimental message reported stronger intentions to confront racism in

their engineering courses compared to men in the control condition, however, intentions to report biases were only significant for reported intentions to confront racism, not sexism. There were not enough women in the study to see the impacts on them.

Cogswell, Cynthia A., Scott Pauls, Adrienne Gauthier, and Erin DeSilva. "Agile and Active: Sustaining Pedagogical Change in a Large-Enrollment Calculus Course." *Journal of Effective Teaching in Higher Education* 2, no. 2 (0 2019): 1–22. https://eric.ed.gov/?q=EJ1236255&id=EJ1236255.

This article examines classroom pedagogical practices in introductory mathematics courses. Using a framework that understands that the lecture is still a very prominent method of instruction, the paper is a case study that examines the effectiveness of active learning strategies in the classroom. While they found that the approach was effective, they also found institutional challenges for faculty to implement and sustain active learning approaches in the classroom. **This article is an example of a single university's promising practice.**

DeMonbrun, M., and M. Brown. "Emphasizing Professional Skills and Professional Values: Investigating the Role of Faculty's Gender and Departmental Gender Diversity." In *2014 IEEE Frontiers in Education Conference (FIE) Proceedings*, 1–8, 2014. https://doi.org/10.1109/FIE.2014.7044119.

This conference paper focuses on engineering teaching faculty at 31 institutions representing over 120 programs in seven engineering disciplines. They wanted to understand if there was a difference between male and female faculty in their choices in the content they emphasize in their course planning for workforce development. They found that "in some academic fields, internal disciplinary influences are strong, arguably stronger than the presence of gender diversity within the organization when considering individual-level forms of influence". At the organizational level, gender diversity in a department is significantly related to the inclusion of professional values in course content. However, the direction of the causal relationship is unclear. From an individual level, women are actually less likely to incorporate professional values into their teaching – albeit with a very small effect size – this finding may suggest that environments where women are in the minority, they may be less likely to focus on course content that addresses the need for diversity in the workforce or take up issues related to gender or diversity out of fear of tokenization.

Killpack, Tess L., and Laverne C. Melón. "Toward Inclusive STEM Classrooms: What Personal Role Do Faculty Play?" *CBE—Life Sciences Education* 15, no. 3 (September 1, 2016): es3. https://doi.org/10.1187/cbe.16-01-0020.

This is an op-ed style article discussing the lack of resources to inform and support faculty's diversity efforts in STEM classrooms. The article states that to support inclusive STEM classrooms faculty "should be 1) minding the privilege gap between our students and ourselves when developing our courses, 2) acknowledging and confronting implicit biases, and 3) mitigating stereotype threat in our classrooms." The article then provides recommendations and suggested readings for each of the three components.

Krishnamurthi, Shriram, and Kathi Fisler. "Data-Centricity: A Challenge and Opportunity for Computing Education." *Communications of the ACM* 63, no. 8 (July 22, 2020): 24–26. https://doi.org/10.1145/3408056.

This article is about the growing inclusion of more introductory data science courses that are not traditional introductory computer science courses. The article argues that these course help meet the needs of more students who need to have some understanding of data science. But, they argue that they create a challenge for introductory CS courses and instead believe there should be a reform of CS courses to include information that makes them more relevant to more students.

Monarrez, Angelica, Danielle Morales, Lourdes E. Echegoyen, Diego Seira, and Amy E. Wagler. "The Moderating Effect of Faculty Mentorship on Undergraduate Students' Summer Research Outcomes." *CBE—Life Sciences Education* 19, no. 4 (December 1, 2020): ar56. https://doi.org/10.1187/cbe.20-04-0081.

This study focused on undergraduate summer research experiences by examining the results of a single program. They found that faculty mentorship was a contributing factor to student success in the program.

Sullivan, Lauren L., Cissy J. Ballen, and Sehoya Cotner. "Small Group Gender Ratios Impact Biology Class Performance and Peer Evaluations." *PLOS ONE* 13, no. 4 (April 3, 2018): e0195129. https://doi.org/10.1371/journal.pone.0195129.

This study focuses on large introductory gateway courses to understand how the gender ratio of small groups influenced student learning in introductory biology courses for non-biology majors. The study examined three sections of an active learning introductory biology course. They found that female-majority groups had a significant, positive influence on student performance regardless of gender, and women's peer- evaluations across three active learning classrooms. They also found that overall, women judged themselves and others more critically than men.

## 4) Barriers Related to Faculty Mentorship

***Faculty are less likely to mentor women in their academic and professional careers.***

See also Bayer 2012

Gelles, Laura, Idalis Villanueva, and Marialuisa Di Stefano. "'Mentoring Is Ethical, Right?': Women Graduate Students and Faculty in Science and Engineering Speak Out." *International Journal of Gender, Science and Technology* 11, no. 1 (June 14, 2019): 108–33. http://genderandset.open.ac.uk/index.php/genderandset/article/view/578.

This article focuses on comparing six case studies to highlight both exemplary and dysfunctional mentoring relationships in higher education. They defined dysfunctional mentoring relationship as one that is "unproductive or characterized primarily by conflict"—as "a mentoring relationship in which the needs of both mentor and mentee are not being met, the long-term costs of maintaining the relationship outweigh the long-term benefits, and the mentor and/or mentee are distressed or harmed." They examined the cases based on how they exemplified or violated six "ethical mentoring" principles (beneficence, nonmaleficence, autonomy, fidelity, fairness, and privacy). They found that two of the six case studies or vignettes depicted a more explicitly positive scenario (beneficence and privacy), while the remaining four demonstrated problematic aspects (nonmaleficence, autonomy, fidelity, and fairness). The study found that

communication was centrally important and an ongoing challenge, everyone was aware of the power dynamics, and there was a need for self-awareness by all parties of the impacts of their actions.

Kricorian, Katherine, Michelle Seu, Daniel Lopez, Elsie Ureta, and Ozlem Equils. "Factors Influencing Participation of Underrepresented Students in STEM Fields: Matched Mentors and Mindsets." International Journal of STEM Education 7, no. 1 (April 21, 2020): 16. https://doi.org/10.1186/s40594-020-00219-2.

This study uses a survey with forty-eight STEM adults in college, graduate school, or recently graduated. The article finds the students' feelings of mentorship based on experience and options. The theme found was the majority of the interviewees would prefer a mentor with the same background (gender and ethnicity). Other conclusions of the study consisted of the need to increase the feeling of STEM belonging through such methods as the media and otherwise involving more diverse STEM professionals.

Moss-Racusin, Corinne A., John F. Dovidio, Victoria L. Brescoll, Mark J. Graham, and Jo Handelsman. "Science Faculty's Subtle Gender Biases Favor Male Students." *Proceedings of the National Academy of Sciences of the United States of America* 109, no. 41 (2012): 16474–79. https://www.jstor.org/stable/41763373.

This study examined whether science faculty members showed preferential evaluation and treatment of the male student to work in their labs by having a nationwide sample of biology, chemistry, and physics professors (n = 127) evaluate an undergraduate application for a science laboratory manager position, with the same materials, which were randomly assigned either the name of a male (n = 63) or a female (n = 64). Participants rated the student's competence and hireability, as well as the amount of salary and amount of mentoring they would offer the student. The study found that both male and female faculty judged a female student to be less competent and less worthy of being hired than an identical male student, and also offered her a smaller starting salary and less career mentoring.

Rodríguez Amaya, Laura, Tania Betancourt, Kristina Henry Collins, Orlando Hinojosa, and Carlos Corona. "Undergraduate Research Experiences: Mentoring, Awareness, and Perceptions—a Case Study at a Hispanic-Serving Institution." *International Journal of STEM Education* 5, no. 1 (April 2, 2018): 9. https://doi.org/10.1186/s40594-018-0105-8.

This study was about the impact of research experiences on 35 undergraduate students at a Hispanic-serving institution (HSI). They found that classification and ethnicity were the strongest predictors of participating in UREs. They found that first-gen and Latinx students were aware of opportunities, but there was no statistical significance by gender. Students did express misconceptions about reasons to participate in UREs and were unable to find mentors.

Ruud, Collin M., Evthokia S. Saclarides, Casey E. George-Jackson, and Sarah T. Lubienski. "Tipping Points: Doctoral Students and Consideration of Departure." *Journal of College Student Retention: Research, Theory & Practice* 20, no. 3 (November 1, 2018): 286–307. https://doi.org/10.1177/1521025116666082.

This mixed-methods study focuses on the responses of 2,070 doctoral students. They found that more non-STEM (32%) doctoral students considered dropping out than STEM doctoral students (24%) and males (36%) were more likely than females (29%) to report that they considered leaving their non-STEM programs. However, STEM females (27%) were more likely than STEM males (22%) to consider leaving. Advising, collegiality, and career preparation significantly predicted a lower likelihood of considering departure. When advising and finances are held constant there is no statistical significance by gender. STEM females also reported less satisfaction than did STEM males on quality of advising and career preparation. Qualitative findings emphasized the importance of advising or mentorship relationships, collegiality, and career preparation in retaining doctoral students. In qualitative responses, STEM females cited issues related to Faculty or Advising 32% of the time, followed by Mismatch of Interests and Goals (22%). Career Preparation was mentioned by only 10% of STEM females, in contrast to 20% of STEM males. In contrast, collegiality in the program was mentioned by only 7% of STEM females, suggesting that relationships with faculty were more important than relationships with peers for this group.

## 5) Barriers related to Academic Structures and Policies

***The institutional barriers that women face in relation to pursuing graduate studies associated with academic structures and policies are more potent when intersected with minority status or identity group statuses.***

Bayer Corporation. "Bayer Facts of Science Education XV: A View from the Gatekeepers—STEM Department Chairs at America's Top 200 Research Universities on Female and Underrepresented Minority Undergraduate STEM Students." *Journal of Science Education and Technology* 21, no. 3 (2012): 317–24. https://doi.org/10.1007/s10956-012-9364-1.

This study used 413 online surveys of STEM department chairs/heads from 213 colleges/universities (sampling criteria is unclear, but they state "top" universities or high % of URM STEM graduates). Almost all of the STEM department leaders believe that increasing diversity is critical, but the majority do not have comprehensive, institution-wide STEM diversity programs in place. Chairs also indicated that they do face challenges with retaining and graduating female STEM students. And they state that the most common challenges that exist for the STEM faculty with their female STEM undergraduates are their own lack of interest and family responsibilities. Engineering and computer science department chairs report greater underrepresentation of females in courses. STEM departments see "weeding out" courses as harmful to URMs, but do not see reasons to change them. Recruitment and retention programs are usually done on the department level and lack of funding is seen as the biggest barrier to adopting these programs. While they acknowledge that URM students face barriers, 26% say their female STEM undergraduates do not face any significant barriers. Department chairs acknowledged that URM and female students are actively discouraged by faculty for pursuing STEM degrees in their department. However, few of the STEM department chairs recognize that this type of counseling may be inappropriate to students.

Goethe, Emily V., and Coray M. Colina. “Taking Advantage of Diversity within the Classroom.” *Journal of Chemical Education* 95, no. 2 (February 13, 2018): 189–92. https://doi.org/10.1021/acs.jchemed.7b00510.

This article is written in an op-ed style and is designed to encourage educators to maximize the potential of STEM fields by capitalizing on diversity in the classroom and institutions to recruit and retain individuals from diverse backgrounds.

Griffith. “Persistence of Women and Minorities in STEM Field Majors: Is It the School That Matters?” *Economics of Education Review* 29, no. 6 (December 1, 2010): 911–22. https://doi.org/10.1016/j.econedurev.2010.06.010.

This study uses longitudinal data on students at a wide range of four-year institutions to examine how student and institutional characteristics affect the decision to persist in a STEM major. The study also looks at where students go when they leave a STEM field major, which STEM majors most students leave from, and when they make this choice. The study finds that students at institutions with more undergraduate students relative to the number of graduate students are more likely to persist, and students at selective colleges with large research expenditures relative to total educational expenditures have lower persistence rates, particularly minority students. For schools with STEM graduate students, a higher percentage of female graduate students in STEM fields has a positive effect on persistence rates of female students.

Luttenberger, Silke, Manuela Paechter, and Bernhard Ertl. “Self-Concept and Support Experienced in School as Key Variables for the Motivation of Women Enrolled in STEM Subjects With a Low and Moderate Proportion of Females.” *Frontiers in Psychology* 10 (2019). https://doi.org/10.3389/fpsyg.2019.01242.

The study examines academic STEM self-concept, while considering socializing factors (perceived family and school support), to understand intrinsic and extrinsic motivations in STEM, and divides STEM fields into those with low engagement of women and those with moderate engagement. This German study looks at university undergraduate students. The study finds that women in STEM subjects with a low proportion of females showed a significantly higher STEM self-concept and significantly higher intrinsic and extrinsic motivations than women in STEM fields with moderate proportions of females. Only school factors contributed to intrinsic and extrinsic motivations.

Mooney, Catherine, and Brett A. Becker. “Sense of Belonging: The Intersectionality of Self-Identified Minority Status and Gender in Undergraduate Computer Science Students.” In *United Kingdom & Ireland Computing Education Research Conference.*, 24–30. UKICER ’20. Glasgow, United Kingdom: Association for Computing Machinery, 2020. https://doi.org/10.1145/3416465.3416476.

This study surveyed 450 undergraduates to understand how they felt about whether they believed they were accepted members of an academic community whose presence and contributions are valued. They found a lower sense of belonging only for female students who self-identified as being part of a minority group.

Ordóñez Franco, Patricia. “Mutually Beneficial Collaborations to Broaden Participation of Hispanics in Data Science.” In *Proceedings of the 26th ACM SIGKDD International Conference on Knowledge Discovery & Data Mining*, 3594–3595. KDD ’20. Virtual Event, CA, USA: Association for Computing Machinery, 2020. https://doi.org/10.1145/3394486.3411075.

This conference paper focuses on mutual collaborations among top tier research universities with community colleges and teaching institutions. It focuses on a collaboration of Computer Science, Mathematics, and Biology faculty in Puerto Rico to create an informal training program for both faculty and students at community colleges and teaching institutions to develop computational biomedical research on campus with the ulterior motive of increasing diversity in computing.

Rivera, Lauren A. “Ivies, Extracurriculars, and Exclusion: Elite Employers’ Use of Educational Credentials.” *Research in Social Stratification and Mobility*, New Directions in Educational Credentialism, 29, no. 1 (January 1, 2011): 71–90. https://doi.org/10.1016/j.rssm.2010.12.001.

This article examines the relationship between education and access to elite jobs. It finds the credential that elite employers seek is no longer the possession of a college or advanced degree but a prestigious one. Firms have created a stratified market for elite jobs based on institutional linkages between schools and employers. Screening also occurs within those elite institutions.

Stathoulopoulos, Konstantinos, and Juan C. Mateos-Garcia. “Gender Diversity in AI Research.” SSRN Scholarly Paper. Rochester, NY: Social Science Research Network, July 29, 2019. https://papers.ssrn.com/abstract=3428240.

This academic conference paper examines the gaps in the gender and ethnic diversity of the AI research and industrial workforce. It expressed the concern that the “lack of gender diversity in AI R&D creates the risk that AI systems ‘perpetuate existing forms of structural inequality even when working as intended’”. Using arXiv they confirm that there is a severe gender diversity gap in AI research, with only 13.83% of authors in arXiv being women. However, 25.4% of the AI publications have been co-authored by a woman, while only 21.04% of the non-AI arXiv papers has a female co-author. Women are also less likely to single-author a paper than men. They found international differences in the gender diversity gap in AI research. They found that women working in countries such as Ireland, Norway, Malaysia or Netherlands, or in particular domains (Physics and Education and Societal) have a higher probability of publishing work related to Artificial Intelligence. They also found that Machine Learning and Data and Informatics have a significantly lower probability of containing at least one female author after controlling for other factors, consistent with the idea that computer science fields face particularly strong issues with gender diversity in AI research. In interviews of the women who were published they noted that their work was less recognized and visible, it was important to have mentors and champions- especially female faculty, there was a need to acknowledge social challenges women face- especially toxic environments, and a need for research opportunities for young scholars.

Szelényi, Katalin, Nida Denson, and Karen Kurotsuchi Inkelas. “Women in STEM Majors and Professional Outcome Expectations: The Role of Living-Learning Programs and Other College Environments.” *Research in Higher Education* 54, no. 8 (2013): 851–73. https://www.jstor.org/stable/24571767.

Using data from 294 women who were in the 2004-2007 National Study of Living Learning survey at 18 different institutions, this study wanted to understand how participation in STEM LL programs and other college environments related to women's STEM outcome expectations. The study found positive relationships between coeducational STEM UL environments and 1) overall professional outcome expectations, 2) women's expectations to achieve career success, and 3) women's expectations to combine a professional career with having a balanced personal life. Women's graduate school aspirations in STEM fields are strengthened by participation in women-only STEM UL programs.

Yen, Joyce, Eve A. Riskin, Cara Margherio, Jan H. Spyridakis, Coleen M. Carrigan, and Ana Mari Cauce. "Promoting Gender Diversity in STEM Faculty through Leadership Development: From Local and National Leadership Workshops to the Online LEAD-It-Yourself! Toolkit." *Equality, Diversity and Inclusion: An International Journal* 38, no. 3 (April 15, 2019): 382–98. https://doi.org/10.1108/EDI-09-2017-0181.

This is a conference paper about the expansion of the ADVANCE leadership program at the University of Washington (UW), which is designed as a program to increase diverse faculty leadership. The paper argues that it is a successful model for department chairs to become advocates of gender equity, diversity and inclusion in STEM.

Wolniak, Gregory C., Radomir R. Mitic, and Mark E. Engberg. "Diverse Pathways to Graduate Education Attainment." *Journal of Diversity in Higher Education* 13, no. 4 (2020): 368–83. https://doi.org/10.1037/dhe0000141.

Using data collected through the Education Longitudinal Study (ELS) on approximately 16,120 students from 2002 (~age 16) to 2012 (~ age 26) the study found that roughly 20% of the sample had completed a graduate degree by the time of the follow-up survey, an additional 14% were enrolled in a graduate program, and the remaining 66% were not enrolled in a graduate program and had not completed a graduate degree. The five major findings of this study were: 1) High SES was only influential for graduate study for White students. 2) Precollege aspirations remain influential as one's likelihood of advancing toward a graduate degree steadily increases if one aspired to complete more education while in high school. 3) Students' academic achievements, particularly earned GPA during college and involvement in college influence graduate education. Overall involvement in the college environment enhanced the likelihood of graduate attainment among Black and Multiracial/Other students, but not for other groups. But, faculty contact outside of class also appears to be primarily beneficial to the graduate education trajectories of White students. 4) There are the significant racial/ethnic differences in the influence of undergraduate majors and institutions attended. 5) There are combined relationships among ascribed (sex and SES) and other precollege (aspirations and academic achievement) factors with subsequent graduate education outcomes across different racial/ethnic groups.

## 6) Barriers related to the Tech Professional Career Landscape

***Women do not perceive that data science careers align with their interests and skills due to workplace cultures, structures, and environments, especially when it comes to balancing their careers with other interests in their lives.***

Berman, Francine D., and Philip E. Bourne. "Let's Make Gender Diversity in Data Science a Priority Right from the Start." *PLOS Biology* 13, no. 7 (July 27, 2015): e1002206. https://doi.org/10.1371/journal.pbio.1002206.

> This is written in a think piece style, designed to emphasize how all stakeholders can influence how gender-diverse the future of data science can be. The paper argues that there is a need to fill data science positions, and this is an opportunity to close the gap in STEM. It indicates that potential barriers are related to the tech professional environment including a "brogramming culture", a professional "chilly climate," and "glass ceiling". They argue the solutions are best designed through changes to professional organizational cultures and individual activism for women in data science.

Cech, Erin, Brian Rubineau, Susan Silbey, and Caroll Seron. "Professional Role Confidence and Gendered Persistence in Engineering." *American Sociological Review* 76, no. 5 (2011): 641–66. https://doi.org/10.1177/0003122411420815.

> This study examines gendered persistence in professional careers during the process of credential acquisition using a sample of undergraduates from four US universities. The study considers the impacts of three potential explanations for women to pursue (or not pursue) higher education credentials or careers. The first factor, family plans, suggests that women who assume the primary responsibility for family care may abandon ambitions in male-typed professions for more family-friendly, female-typed ones. The study finds that while this may prevent women later in their career or from entering the field, they found no evidence that women's family plans lead to their attrition from engineering once they enter engineering training. However, men with strong family plans seeking an engineering degree are less likely to pursue a career in engineering. The second factor, self-assessment, argues that women have a low self-assessment of the skills required for success in engineering. The study found that math self-assessment does not significantly predict persistence in an engineering major or intent to be an engineer in the future. They examined a third factor, professional role confidence, which refers to individuals' confidence in their ability to fulfill the expected roles, competencies, and identity features of a successful member of their profession. They looked at two aspects of this factor, expertise confidence, or confidence in one's ability to wield the competencies and skills required of practice in the profession, and career-fit confidence, or confidence that a profession's career path is consonant with one's individual interests and values. They found that professional role confidence is cultivated more successfully in men than in women engineering students.

Correll, Shelley J. "SWS 2016 Feminist Lecture: Reducing Gender Biases In Modern Workplaces: A Small Wins Approach to Organizational Change." *Gender & Society* 31, no. 6 (December 1, 2017): 725–50. https://doi.org/10.1177/0891243217738518.

> In this overview of the research of the Clayman Institute, Correll begins by pointing to the evidence that gender stereotypes lead to biases that negatively affect the evaluations and

experiences of women at work. Gender biases lead equally qualified men and women to be evaluated differently. Women are subjected to a higher bar, requiring more evidence than men to be seen as qualified. Gender stereotypes also lead to shifting criteria where evaluators more heavily weigh the criteria evidenced in men, where in both conditions, participants preferred the man applicant, justifying their choice by shifting or redefining the criteria for success at the job. Stereotypes also often lead to a double bind in which judgments of competence and likability are negatively correlated for women, but not men. For all of these stereotypes, gender bias is amplified when decision-making contexts are ambiguous. Both unconscious bias training and formalized organizational processes can lead to some decrease in gender biases and some improvements in gender diversity. The small wins model begins with educating managers on a gender framework about stereotyping and bias. The second step, diagnosing bias is important for selecting a target of change, creating a baseline for assessing the effectiveness of a change effort, and motivating managers to be a part of the change process. The third step is to work with managers to develop new procedures or other tools to reduce gender bias in organizational processes. Steps four and five are intervening and evaluating.

DiDonato, Lisa, and JoNell Strough. "Do College Students' Gender-Typed Attitudes About Occupations Predict Their Real-World Decisions?" *Sex Roles* 68, no. 9–10 (2013): 536–49. https://doi.org/10.1007/s11199-013-0275-2.

This study examines how US college students' decisions in selecting college majors and careers are related to their gender-type attitudes about preferred occupations. They surveyed 264 college students (165 females/ 99 males) at one university. They found that both women and men expressed the attitude that it is more appropriate for women to hold stereotypical masculine jobs than it is for men to hold stereotypical feminine jobs. They also found that women held gender stereotypical attitudes about their self-preferred occupations, however men's attitudes were unrelated to their decisions.

Duranton, Sylvain, Jörg Erlebach, Camille Brégé Jane Danziger, Andrea Gallego, and Marc Pauly. "What's Keeping Women Out of Data Science?" BCG Global. BCG Global, January 8, 2021. https://www.bcg.com/publications/2020/what-keeps-women-out-data-science.

This article surveyed 9000 STEM students or recent graduates across Australia, Canada, China, France, Germany, India, Japan, Spain, UK, and the US. The research explores the surveyees' image and awareness of data scientists and data science careers. Several themes emerged including the lack of understanding of what a data scientist does by both men and women and the misconceptions that the career is overly competitive and lacks real purpose.

Friedmann, Enav. "Increasing Women's Participation in the STEM Industry: A First Step for Developing a Social Marketing Strategy." *Journal of Social Marketing* 8, no. 4 (October 8, 2018): 442–60. https://doi.org/10.1108/JSOCM-12-2017-0086.

This study surveyed 248 participants from the US, UK, Canada, and Australia, including 121 men and 125 women. They found that women's most important consideration of choosing a career was salary, but this consideration was slightly less important than among men. Low level of ability to combine work and family decreased the job's value for women more than for men,

while moderate and high ability increased the value of career choices more for women. The study concludes by arguing that companies need to make changes in the workplace reality by decreasing barriers and adding benefits and not just communicate the right message about increasing the value of STEM careers to women.

Stoet, Gijsbert, and David C. Geary. "The Gender-Equality Paradox in Science, Technology, Engineering, and Mathematics Education:" *Psychological Science*, February 14, 2018. https://doi.org/10.1177/0956797617741719.

This study used the most recent and largest international database on adolescent achievement and confirmed that girls performed similarly or better than boys on generic science literacy tests in most nations. At the same time, women obtained fewer college degrees in STEM disciplines than men in all assessed nations, although the magnitude of this gap varied considerably. They argued that paradoxically, countries with lower levels of gender equality had relatively more women among STEM graduates than did more gender-equal countries, which may have to do with the relative value of STEM careers in those countries.

"Women in Data Science and AI." The Alan Turing Institute, August 10, 2020. https://www.turing.ac.uk/research/research-projects/women-data-science-and-ai.

This study asks why so few women enter and stay in data science and AI careers in the UK. The article also questions how this issue affects the fields and what has worked to fix this. Findings include 56% of women leaving their companies 10-20 years into their careers and 51% of that group leaves their fields altogether. The Turing Institute cites sexism, bullying, sexual harassment, gender pay gap, slow career progression for women, male-dominated office culture, lack of access to mentors, and gender bias in hiring as reasons for this occurring. No method was found to assuage this.

Wynn, Alison T, and Shelley J Correll. "Puncturing the Pipeline: Do Technology Companies Alienate Women in Recruiting Sessions?" *Social Studies of Science* 48, no. 1 (February 1, 2018): 149–64. https://doi.org/10.1177/0306312718756766.

This article focuses on recruiting by tech firms and how they create climates that do not attract women. The study focused on observations of on-campus tech recruiting sessions. They found tech companies were likely to recruit with presentations and discussions that excluded women, the pervasive use and enforcement of gender stereotypes in content, presentations with extreme technicality, and references to masculine geek culture. They also found that larger, more established companies were less likely to project gendered recruitment presentations. Finally, they found that women asked questions in 65 percent of the sessions with positive behaviors; in sessions without these positive behaviors, women asked questions only 36 percent of the time.

Xu, Yonghong Jade. "Attrition of Women in STEM: Examining Job/Major Congruence in the Career Choices of College Graduates." *Journal of Career Development* 44, no. 1 (February 1, 2017): 3–19. https://doi.org/10.1177/0894845316633787.

This study focuses on the career choices of college students to understand if their career paths are consistent with their academic training. The study finds that the number of college students choosing a STEM major remains low (<15%), female presence in STEM majors remains low (< 36%), and gender inequality (salary and employment status) in STEM occupations is significant from the beginning of post-college employment. While the study found that positive career outcomes, including better earnings and greater job satisfaction, are associated with individuals having an occupation congruent with their college major, and that STEM graduates have a lower unemployment rate than non-STEM graduates, it also found that gender-based inequity in STEM majors and during the labor market entry stage is severe, and women experience clear disadvantages in salary and employment status.

## 7) Barriers related to Awareness, Information, and Misinformation

***Women have access to information about the existence of data science and AI degrees and resources, but do not perceive graduate degrees as connected to viable career pathways or have information that leads them to believe that there is a connection.***
See also Rodríguez et al. 2018.

Carter, Lori. "Why Students with an Apparent Aptitude for Computer Science Don't Choose to Major in Computer Science." *ACM SIGCSE Bulletin* 38, no. 1 (March 3, 2006): 27–31. https://doi.org/10.1145/1124706.1121352.

This article sought to understand whether students, male or female, don't pursue education in computing fields because they either have no information or incorrect information about what the study of computing involves and what sorts of careers are available to computing professionals. They surveyed 836 high school students (363 men, 423 women, 50 declined to say) from nine different schools in California and Arizona and found that high school students were severely lacking in experience with computing, particularly in formal classroom experience, and that the vast majority of students were unaware of careers in computer science. Female students were most interested in using computer science degrees in other fields.

Gruenbacher, D. M., B. Natarajan, A. Pahwa, C. Scoglio, C. Lewis, and M. Muguira. "Increasing Women Graduate Students in STEM Fields through a Focused Recruitment Workshop." In *2007 37th Annual Frontiers In Education Conference – Global Engineering: Knowledge Without Borders, Opportunities Without Passports*, S2H-9-S2H-13, 2007. https://doi.org/10.1109/FIE.2007.4418076.

This conference paper reports on the implementation of a workshop to increase women's awareness of graduate programs. It reports that the workshop was well-received, but does not provide information on effectiveness at increasing graduate enrollment or whether lack of information is a real or perceived barrier.

Hambrusch, Susanne, Ran Libeskind-Hadas, and Eric Aaron. "Understanding the U.S. Domestic Computer Science Ph.D. Pipeline." Communications of the ACM 58, no. 8 (August 2015): 29–32. https://doi.org/10.1145/2790854.

This article consists of two studies: 1) interviews of PhD recipients undergraduate experience and 2) analyses of 14 doctoral programs' applications, acceptances, and matriculation rates. The study found low rates of acceptance and even lower matriculation rates for top ten graduate programs. Female applicants consisted of 14% and African Americans and Hispanic/Latino were 3% each of the application pool. A large number of female students attended TOP25 liberal arts colleges, but had a small fraction of African American and Hispanic students. RU/VH-25 producer institutions had a large population of Hispanic applications and RU/H and BAC-25LA had a large population fo African American applicants. The article advocates for a partnership between undergraduate and graduate schools and an increase and advertisement of undergraduate research.

Jackson, Kristyn, Tori Bailey, Sheri Sheppard, and Helen Chen. *Graduate School or Not? Engineering Students Consider Continuing Their Education in Co-Terminal Programs. Research Brief*. Center for the Advancement of Engineering Education, 2008. https://eric.ed.gov/?id=ED540676.

This research brief covers a longitudinal study of 10 students seeking to pursue a BS/MS dual degree program. They found that students were not simply being funneled into the graduate program. However, reasons for obtaining the degree varied between always having planned to pursue a masters and not having other plans post-graduation.

Knight, D. B., B. J. Novoselich, and L. C. Trautvetter. "Expanding Women in Undergraduate Engineering: A Mixed-Methods Analysis of Recruitment Cultures, Practices, and Policies." In 2014 IEEE Frontiers in Education Conference (FIE) Proceedings, 1–8, 2014. https://doi.org/10.1109/FIE.2014.7044067.

This mixed-methods study interviewed 468 college students, faculty and administrators from six different institutions and used a nationally representative survey of faculty and administrators from 31 different institutions. The study finds three themes across the surveys: institutional commitment and self-awareness, strategic admissions policies and "high touch" efforts, and integrated outreach programs. The case study institutions were found to have high diversity recruitment efforts consistently, but the national representative study did not. The article advocates for higher incentives and involvement for the faculty to recruit more diverse students.

Maheshwari, Sharad K., Anne L. Pierce, and Enrique G. Zapatero. "Understanding the Lack of Minority Representation in Graduate Programs in Computer Science and Information Technology: A Focus Group Study of Student Perceptions." *Academy of Information & Management Sciences Journal* 12, no. 1/2 (January 2009): 71–90. https://stanford.idm.oclc.org/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=47962309&site=ehost-live&scope=site.

This study collected data from six informal focus groups of undergraduates at three institutions followed by a survey of 153 students. It found that students lacked information about the graduate application process, clarity of what coursework was needed for preparedness, and whether there was a poor market value (perceived or real) of graduate education. The study did not find differences between male and female students.

## 8) The Role of Peer and Community Social Relationships

***Peer, role models, mentors, and community networks can serve as significant protective factors for women pursuing degrees or persisting in data science or AI.***

Espinosa, Lorelle. "Pipelines and Pathways: Women of Color in Undergraduate STEM Majors and the College Experiences That Contribute to Persistence." *Harvard Educational Review* 81, no. 2 (June 1, 2011): 209–41. https://doi.org/10.17763/haer.81.2.92315ww157656k3u.

> This study uses a large sample of US undergraduates to determine whether or not women who remain enrolled in college persist in STEM between the freshman and senior years using a hierarchical generalized linear model (HGLM). The study finds that while father's education (less than college) and financial concern (college affordability) were significant for White women, none of the parental socialization measures proved significant for women of color. For women of color in STEM fields, the college experience and college environment prove more important relative to high school performance and family background characteristics for persistence in STEM. Women of color who frequently engaged with peers outside the classroom to discuss course content, joined STEM-related clubs and organizations, and participated in undergraduate research programs are more likely to persist in STEM. This may serve as evidence that academic peer relationships are especially important.

Schilling, Malle, and Margaret Pinnell. "The STEM Gender Gap: An Evaluation of the Efficacy of Women in Engineering Camps." *Journal of STEM Education: Innovations & Research* 20, no. 1 (April 2019): 37–45. https://stanford.idm.oclc.org/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=aph&AN=139832865&site=ehost-live&scope=site.

> This study focuses on the efficacy of both co-ed and single-sex female engineering summer camps at increasing interest and self-efficacy in engineering for incoming undergraduates, by using survey data from 234 participants at engineering camps hosted by the University of Dayton. They found that a single-sex engineering camp model can have more positive effects on the self-efficacy of the young women who attend and participate.

Zawistwska, Alicja. "Is Entering STEM Socially Contagious? Contextual Factors in Women's Educational Decisions." *Polish Sociological Review*, no. 197 (2017): 51–66. https://www.jstor.org/stable/26383066.
Zuazu-Bermejo, Izaskun. "Cultural Values, Family Decisions and Gender Segregation in Higher Education: Evidence from 26 OECD Economies," 2018. https://doi.org/10.13140/RG.2.2.12519.75682.

> This qualitative study in Poland looked at the influence of significant role models in women's selection of specific STEM fields when entering their undergraduate studies. It found that women with significant STEM role models or more family income had more information about potential STEM career options.

## 9) The Role of Family Relationships in STEM Leadership

***Family work-life balance does not appear to be a significant barrier early in data science or AI careers or graduate studies for women. However, having a family may become a challenge later on for***

***women in STEM leadership positions. On the other hand, family networks can serve as a significant protective factor for pursuing degrees or persisting in data science or AI.*** *See also Buse et al. 2013; Chech et al. 2011; Espinosa 2011.*

Brue, Krystal. "Work-Life Balance for Women in STEM Leadership." *Journal of Leadership Education* 18, no. 2 (April 15, 2019). https://doi.org/10.12806/V18/I2/R3.

> This article focuses on the work-life balance of women in STEM leadership roles that are traditionally filled by men. The article is based on the results of a survey of 39 women in STEM leadership career positions. The women in these positions indicated that social networks of spouses/significant others, female coworkers, mentors outside the organization, and family members provided support for them to be able to have WLB and success in these roles.

Cidlinská, Kateřina. "How Not to Scare off Women: Different Needs of Female Early-Stage Researchers in STEM and SSH Fields and the Implications for Support Measures." *Higher Education* 78, no. 2 (August 1, 2019): 365–88. https://doi.org/10.1007/s10734-018-0347-x.

> Focused on European researchers, this article states that female researchers tend to drop out of their academic careers at different periods. They give the examples that in the natural and technical sciences (STEM), it is in the postdoctoral phase, whereas in the social sciences and humanities (SSH) it is during the doctoral phase. The paper argues that this is related to professional identity obstacles and how they differ at different points in career trajectories.

Myers, Dante P., and Debra A. Major. "Work–Family Balance Self-Efficacy's Relationship With STEM Commitment: Unexpected Gender Moderation." *The Career Development Quarterly* 65, no. 3 (2017): 264–77. https://doi.org/https://doi.org/10.1002/cdq.12097.

> This article is about the challenge of retaining undergraduates in STEM majors. The study found that at high levels of confidence in ability to balance work and family roles, men and women are similarly committed to a STEM career.

Puccia, Ellen, Julie P. Martin, Chrystal A. S. Smith, Gladis Kersaint, Rebecca Campbell-Montalvo, Hesborn Wao, Reginald Lee, John Skvoretz, and George MacDonald. "The Influence of Expressive and Instrumental Social Capital from Parents on Women and Underrepresented Minority Students' Declaration and Persistence in Engineering Majors." *International Journal of STEM Education* 8, no. 1 (March 19, 2021): 20. https://doi.org/10.1186/s40594-021-00277-0.

> This study interviewed 55 students recruited from 11 universities across the US to understand the role of parents on students' persistence in engineering majors. They found that in high school parents were influencers, they provided instrumental and expressive advice, information, and support when students were choosing a major and throughout their first year of college. Throughout college they also provided instrumental and expressive advice leading to persistence.

Rankin, Yolanda, Maedeh Agharazidermani, and Jakita Thomas. "The Role of Familial Influences in African American Women's Persistence in Computing." In *2020 Research on Equity and Sustained Participation in Engineering, Computing, and Technology (RESPECT)*, 1:1–8, 2020. https://doi.org/10.1109/RESPECT49803.2020.9272503.

This conference paper examines how African American women in computing leverage familial relationships to gain greater access to career opportunities, including educational preparation and professional development. The study interviewed 34 women at various stages in their profession. They found that families provided: 1) exposure and access to computing; 2) support for self-efficacy; 3) education as a family value; 4) resource for career guidance & advice; 5) emotional support; and 6) family members as role models.

Su, Xuhong, and Barry Bozeman. "Family Friendly Policies in STEM Departments: Awareness and Determinants." *Research in Higher Education* 57, no. 8 (2016): 990–1009. https://doi.org/10.1007/s11162-016-9412-4.

This study explores the knowledge gap on family friendly policies among chairs of STEM departments. The study found little evidence of family friendly policies, and more female faculty in STEM departments was not linked to a push for more departmental awareness of family friendly policies. However, female chairs are more aware of family friendly policies.

## Misc.

Margolis, Jane, Allan Fisher, and Faye Miller. "The Anatomy of Interest: Women in Undergraduate Computer Science." *Women's Studies Quarterly* 28, no. 1/2 (2000): 104–27. https://www.jstor.org/stable/40004448.

"Science and Engineering Labor Force | NSF - National Science Foundation," 2020. https://ncses.nsf.gov/pubs/nsb20198/demographic-trends-of-the-s-e-workforce.