



# ADVANCING WOMEN IN LEADERSHIP

---

---

VOLUME 40, 2021  
ISSN 1093-7099

---

---

---

---

EDITORS: BEVERLY J. IRBY, BARBARA POLNICK, NAHED ABDELRAHMAN

---

---

*Full Length Research Paper*

# Women in Computer Science and Engineering: A Transformational Leadership Approach to Gender Equity

Lindy Ryan, Eduardo R. Díaz, Arron P. Grow

Lindy Ryan, Professor and Researcher, Rutgers Discovery Informatics Institute, Rutgers University, [lindy.ryan@rutgers.edu](mailto:lindy.ryan@rutgers.edu)  
Eduardo R. Díaz, Associate Professor, School of Business and Administration, CETYS Universidad, [eduardo.diaz@cetys.mx](mailto:eduardo.diaz@cetys.mx)  
Arron P. Grow, Faculty, Clover Park School District, [arrongrow@hotmail.com](mailto:arrongrow@hotmail.com)

Accepted November 19, 2020

The underrepresentation of women in science, technology, engineering, and mathematics (STEM) is a phenomenon that needs to be addressed from an educational perspective. Within the domains of computer science and engineering (CS&E) the gender imbalance is even more acute as the underrepresentation of women not only persists but has increased over the past few decades (Corbett & Hill, 2015; Master et al., 2016). In this paper a discussion of the current situation of women's underrepresentation across broad CS&E domains is presented. This will be demonstrated through a review of research into the historical factors and institutional practices that have been ongoing barriers to the inclusion of women in CS&E. Then, a discussion of how transformational leadership theory can serve as a tool for change to help scholars better understand the present situation, and then guide practitioners in overcoming it, is presented. To this end, the paper concludes with a discussion of how diversity and inclusion ideas, based on a transformational leadership approach, can improve gender equity in CS&E.

**Keywords:** underrepresented, women, gender, transformational, leadership

## Introduction

The disproportionately low share of women in science, technology, engineering and mathematics (STEM) domains is well documented in the scholarly literature (Aguinis et al., 2018; Fatourou et al., 2019; Hill et al., 2010; Sekaquaptewa, 2011; Szelenyi et al., 2013; Zafar, 2013). According to Corbett and Hill (2015) as well as Master et al. (2016), the underrepresentation of women in engineering fields—especially in leadership roles—has not only persisted in recent decades, but has increased. This deepening gender imbalance lends unique urgency to exploring and overcoming institutional barriers that affect and depress women's long-term inclusion in broad computer science and engineering (CS&E) domains.

Pawley et al. (2016) reviewed published articles in the *Journal of Engineering Education* from 1998 to 2012. They argued that while individual articles were noteworthy, most of them focused on a narrow range of theoretical approaches, tended to use undergraduate students as participants almost exclusively, described gender simply in binary as male or female, and focused on educational inputs rather than performance. As the problem of women's underrepresentation in CS&E and STEM remains insufficiently examined, McKinney et al. (2008) as well

as Kim et al. (2008), reported that the percentage of computing jobs held by women has fallen significantly over the past 23 years. More recent research found that women are outnumbered by men six to one in leadership positions in computing fields (Corbett & Hill, 2015). This marginalized faction of women has become known as what Margolis and Fisher (2002) referred to as “survivors of the ‘boys club’ of high-school computing” (p. 49).

The lower number of women studying in CS&E programs represents a pipeline problem. Many studies on women's participation as authors in research publications have been conducted over the past decade to understand gender inequality in academia and the impact of policies and practices that may perpetuate continued underrepresentation of women researchers across a wide variety of computing disciplines (Agarwal et al., 2016; Aguinis et al., 2018; Cavero et al., 2015; Cohoon et al., 2011; Vela et al., 2012). Several studies have already addressed the gender imbalance in engineering fields, including the work published by Dimitriadi (2013), Agarwal et al. (2016), and Lewis (2018). Their research found gender gaps in all areas of CS&E academics, including number of students, faculty (tenured and non-tenured), and research personnel. This deficit is not only impactful in women's roles as leaders in academia; it also affects

the rate at which young women enroll in CS&E courses per Bottia et al. (2015), who found that the availability of female faculty was a contributing factor to women's retention and terminal efficiency in academic programs in this field.

Finally, a widening gender gap in CS&E not only perpetuates an imbalance of women in STEM at large, but has specific, wider consequences in the larger CS&E economy, which is expected to continue to grow (Bureau of Labor Statistics, 2015; Dockterman, 2014). Thus, this issue of underrepresentation in CS&E represents a larger and urgent organizational problem: women comprising only a quarter of the computer science workforce and the number is declining. Not only is closing the gender gap in CS&E at risk, but so is meeting the incredible workforce demand of the big data era. We believe the continued underrepresentation of women in CS&E across industry and academic domains are not mutually exclusive phenomenon, but are interrelated issues that form a larger diversity imperative of increasing inclusion of a historically underrepresented population. We argue that creating transformational organizational cultures can help address the gender in CS&E domains.

Though recent scholarship traversing the historic underrepresentation of women in CS&E has provided much impetus for new programs and interventions intended to increase the inclusion of women, many are in nascent stages. Kim et al. (2008), as well as Szelenyi et al. (2013), and most recently Gailliard and Batmanian (2016), provide research and discussions that address underrepresentation of women in CS&E. Considered together, these researchers have found that strategies such as early socialization and role model mentorship, research experiences for undergraduates, and living-learning programs exist in practice. Thus far, however, the consensus appears to be that such efforts, while having potential for improving underrepresentation of women in CS&E, need to be embraced across educational institutions to create significant change. This requires educational institutions, specifically academic programs in STEM, to transform their culture in a way that diversity and inclusion are valued as essential parts of the overall strategy for the future of CS&E field.

### **Factors Affecting Underrepresentation**

Inquiry into women's underrepresentation in CS&E has been ongoing for some time. Valian (1999) presented evidence that women are disadvantaged both by gender schemas that favor men in technology and by the compounding accumulation of male advantage over time. Later, in a controversial speech by a former Harvard University President, three hypotheses were provided as possible explanations for the historic underrepresentation of women in CS&E. These included (a) different innate aptitudes in mathematics and high-end technology skills; (b) different career-related preferences among men and women; and (c) simple, overt discrimination (Summers, 2005, as cited in Reuben et al., 2014). While mounting evidence against the aptitude-based hypothesis and career-based dichotomy have been since revealed in the literature (Guiso et

al., 2008; Hyde et al., 2008), other notable recent findings have indeed illuminated the ongoing pervasiveness of historical biases. These include, but are not limited to, perceptions of women's competency in computer science, the larger share of employment opportunities for men, and a lack of dynamic mentorship programs and STEM advocacy for women. According to Corbett and Hill (2015), all these issues remain ubiquitous barriers for women in computing.

In addition to these, Szelenyi et al. (2013) pointed out that several personal and environmental factors affect women's career-related outcomes in CS&E. Moreover, Ehrlinger et al. (2018) noted that career choices for women continued to be influenced by engineering prototypes based on stereotypical gender beliefs that discourage women from entering CS&E fields. Therefore, there continued to be a need to address issues such as early socialization of and education in CS&E identity, attitudes of self-efficacy, and issues related to status and stereotypes. The research cited here suggest that the problem of women underrepresentation in CS&E goes beyond the existence of male-dominated workplaces but stretches all the way back to early educational experiences.

### **Systemic Barriers to Women in CS&E**

Given even this relatively brief review of the research literature, it should be clear that there are many obstacles to women in CS&E, and that raising this issue in the scholarly record is not a new attempt. For this reason, we would like to take a different approach to facilitating a constructive conversation on overcoming barriers to increase inclusion of women in CS&E going forward. Thus, rather than itemizing difficulties, we propose two general categories of systemic barriers be considered as areas that perpetuate divergence of women from pursuing advanced education and careers in CS&E, expanding on McKinney et al.'s (2008) idea of an input and throughput theorem which describes the disparity between women and men existing in engineering professions. Described in general terms, these are an *entry* problem, wherein women do not enter (or are not prepared to enter) computer science domains and a *continuity* problem, wherein entry does not persist meaningfully into leadership.

The following literature review encompasses research on both the *entry* and *continuity* problems to distill salient, recurrent themes that offer insight on fundamental issues affecting ongoing underrepresentation of women in CS&E, and describes what researchers have concluded to be useful approaches to meaningful interventions. Going forward, these will form a framework for further discussions on how to overcome long held institutional barriers to gender equity in CS&E by transforming educational cultures.

### **The Entry Problem**

We identify *entry* problems as issues concerned with women not developing early STEM identity or sustainably connecting with broader CS&E domains through educational programs or socialization. Reuben et al. (2014) found that standardized test

results indicate that high-school-aged girls are as prepared as boys to pursue science majors in college. However, this readiness does not correspond to enrollment of women in computer science majors. Their work affirms what Hughes et al. (2013) had already been pointing towards: that entry problems begin foremost with the rate at which women enter early CS&E educational programs, and that marginalization begins to occur at adolescence. More specifically, research conducted by the American Association of University Women (2010) suggested that the ages between 10 and 15 are the period during which students, particularly girls, begin to lose interest in science and mathematics, as well as when the gender gap in terms of standardized STEM test scores begins to evidence. Thus, we can further delineate *entry* problems into the following two areas where barriers have been suggested to occur: during pre-college education and socialization (K12), and early college experiences.

**Pre-college education and socialization (K12).** Looking into the efficacy of middle school participants' STEM identity formation, researchers Hughes et al. (2013) studied the influence of activities within informal science and engineering learning environments. While the study did not show a significant difference in the two informal programs evaluated (an all-girls' STEM camp and a co-educational STEM camp), it did provide findings that raised the issue of access, particularly with pedagogy, and advocated for STEM curricula approaches that consider the unique learning styles of young women. Additionally, explicit exposure of female role models resulted in an increased interest in STEM fields, among them CS&E.

Further research conducted with middle-school students suggested that gender segregation in STEM is affected by teachers who take part in shaping the worldview of students at an early age. One example of research that points to this is Shapiro et al. (2015). Their research followed that of Riley (2014) who stated that teachers who unknowingly make gender-based distinctions have profound influence on their students and unintentionally lead them to conform to biased educational expectations. Both investigations added support for what Dimitriadi (2013) and Tajlili (2014) also concluded: that one angle of the entry problem is how the influence of parents, teachers, and guidance counselors and other role models early in a student's educational journey affect long-term student choices in education and career trajectories.

Hughes et al. (2013) also found that exposure to female role models improved self-concept, a broadened view of STEM careers possibilities, and generated a sense of belonging, suggesting that early and informal STEM education programs can positively influence learned STEM identity. Again, the need for role models and mentorship was highlighted in this study.

**Early-college experiences.** Appropriately, several efforts have been undertaken to move beyond K12 grade level and pre-college barriers to study the early college experiences that act as further entry barriers to women advancing in computer science programs (Cheryan & Meltzoff, 2016). Several previous studies have found that programs early in the collegiate journey that

include programmatic elements designed to promote gender equity are effective in promoting long-term interest in computer science, particularly among underrepresented groups such as women, and especially so when supported by ongoing mentorship with faculty members (Barker, 2009; Jesse, 2006). Two recent notable studies in this category focused on building on previous research that sought to address issues of women's underrepresentation in CS&E.

One study was conducted through an NSF-funded project at the Center for Embedded Network Sensing (CENS) at UCLA to explore whether Research Experiences for Undergraduates (REU) promote women's long-term interest in CS&E domains. In their study of REUs, researchers Kim et al. (2011) reviewed specific mentoring, programming, and professional development mechanisms that benefited female students. Results from the study found several gender equity building strategies, including having a critical mass of women in the program, providing role models and mentors to support participation, and indirectly (as opposed to directly) introducing sensitive gender equity topics like work/family balance. Findings from Kim et al. (2011) also support retention in CS&E programs through faculty mentorship, fostering community building through structured groups, and sharing of individual progress. Overall, the need for a strong faculty mentorship component was deemed particularly influential in women's decisions to move beyond undergraduate programs and pursue advanced degrees.

On this matter of entry, other programs that merit attention are those referred to as living-learning programs (L/L). Looking into living-learning programs, Szeleynyi et al. (2013) found that variables of socioeconomic status, high school grades, and pre-college self-efficacy were statistically significant predictors of involvement in STEM-related studies. This further reinforces earlier findings that suggest STEM identity and self-efficacy begin in adolescence, and the middle school years are perhaps those most sensitive to STEM formation (AAUW, 2010; Hughes et al., 2013; Spielhagen 2008). It is also worth noting that similar to studies already reviewed, Szeleynyi et al. (2013) found that women who engaged with female peer and faculty mentors enjoyed a "safe space" (p. 866) that facilitated persistence in science and engineering graduate education as well as confidence in career success across broad science domains.

For their part, Cerf and Johnson (2016) found that teachers who spend time listening to students and inspiring them to stay the course are likely to contribute positively to student retention, especially with minority and female students in CS&E undergraduate programs and influence their academic and professional success. These researchers, along with Fatourou et al. (2019), voiced what we too assert, that schools have a responsibility to help fulfill industry needs for talent despite the challenges they may face in doing so. In their research, they found that while enrollment numbers in CS&E programs have consistently risen, the issue of lack of diversity represents a problem in terms of social justice, size of the talent pool, and available perspectives to inform in product design processes.

## The Continuity Problem

The second set of systemic barriers to women's underrepresentation in CS&E are those we classify as *continuity* problems: situations wherein women enter CS&E academic programs or professional careers, but either leave or are marginalized to the point of essential exclusion and thus do not achieve a significant share of leadership positions.

Though several suppositions have been offered as reasons for women's underrepresentation in CS&E and how this impacts their leadership roles throughout academia and industry, McKinney et al. (2008) launched a large-scale study to distinguish fact from supposition by examining attitudes and experiences of 815 male and female IT professionals in the US. Their work suggests potential causes of underrepresentation and support the assumption that fewer women entering CS&E professions exacerbate the underrepresentation problem.

First, results suggested that men and women share some but not all motivations for entering CS&E professions. For example, men were far more likely to cite love of technology as a key motivator, while women more often indicated job security and flexible work hours, thus suggesting that factors in the work itself were more important than actual career decision (McKinney et al., 2008). Regarding socialization and the effect of appropriate role models, two areas that have historically been causal to lower levels of learning providing a plausible explanation for women's underrepresentation. Results suggested that while there was no significant difference in the influence of professional role models—a finding that is contrary to assumed and documented disadvantages for women, especially at the undergraduate or entry-level (Ahuja, 2002; Kim et al., 2011)—women did have a vastly different socialization experience where learning was focused primarily on the social aspects of CS&E whereas men reported stronger socialization in regard to the technical aspects. These resulted in statistical significance ( $p < .001$ ) in both comfort with technical language and technical skills (McKinney et al., 2008).

Of note in McKinney et al.'s (2008) study were the reported gender differences across work-related experiences, specifically in regard to perceptions of supervisor support for career success. They concluded that there are gender differences in the treatment and experiences of men and women in CS&E, which were consistent with historical findings in greater attention is needed on the supply side of the underrepresentation issue, early identification and socialization with technology, and attention to female learning styles in computer science.

Interestingly, stereotypes that impair women's careers in CS&E are not limited to male-female biases, but women enact these same biases upon themselves. One finding in this area of research came from Reuben et al. (2014) who found that while there was no gender-based disparity in performance, a strong bias existed among both males and females to hire male candidates. The researchers found that when employers received subjective information about candidates' performance, the gap

increased: females were chosen only 32% of the time, and male candidates were selected 85.7% of the time. This suggests that not only are negative stereotypes against women's aptitudes pervasive, but that both men and women may discriminate against women without realizing it, leaving room for further research into why.

## A Transformational Approach to Overcoming Barriers to Equity in CS&E

This section argues the point that educational organizations need to create transformational organizational cultures where female students can find role models and mentors that can help them overcome the entry and continuity problems noted before. According to Northouse (2016) "transformational leadership is the process whereby a person engages with others and creates a connection that raises the level of motivation and morality in both the leader and the follower" (p. 163). Northouse's definition is consistent with earlier works developed by Burns (2010), Bass (1985), and Kouzes and Posner (2019). These authors believed that effective leaders understand the importance of ensuring follower buy-in to achieve superior results in a variety of contexts. They noted that the leader-follower relationship creates a transformation that is manifested at the individual, group, and organizational level. Kouzes and Posner paid special attention to making sure educators understand how their work is essential shaping the perspectives and perceptions of self of students.

To this end, we espouse an adaptation of four leadership factors connected with transformational leadership. As discussed by Northouse (2016) these are the abilities to act as strong role models for others, inspire and motivate, foster intellectual stimulation, and provide individualized consideration while influencing toward a desired goal. Adapting these factors for the purposes of the present discussion, the connected skills and actions would be the following. First, becoming ready and willing to influence women toward CS&E-related careers; second, motivating women to not only become involved in CS&E-related careers, but inspiring them toward longer-term involvement and leadership in these fields. Third, providing intellectual challenges connected to CS&E thinking and endeavors, which encourage innovation and creativity as a standard practice. Finally, being skilled at addressing individual concerns about moving toward CS&E-related domains and becoming adept at meeting individual needs of women who pursue CS&E-related careers.

In the context of the present discussion, we look for influencers to be mindful of these four factors while they engage in actions typically connected with transformational leadership, e.g. coaching, mentoring, and other activities that inspire and support female students and workers and align with demonstrated effective practices in numerous studies (Díaz et al., 2019; Kouzes & Posner, 2019). To better explain how transformational leaders can help reduce educational, social, and organizational barriers for women in CS&E, we will address each of these barriers separately.

**Overcoming Barriers in Education.** Some schools have created programs designed to motivate female students to enroll in engineering courses designed and taught by teachers engaged in promoting gender diversity in CS&E (Fortenberry & Cady, 2009). Once female students enroll in science and engineering programs, the issue of retention takes on a gender approach, as these students tend to be more aware of the gendered effects of their discipline than their male colleagues (Morganson et al., 2015). Thus, the need to reconsider pedagogical and curriculum design practices on the part of educators becomes a subject for discussion (Brotman & Moore, 2008, as cited in Hughes et al., 2013).

Transformational leaders in the education industry are likely to engage in behaviors that are gender neutral. These leaders promote educational environments where educators can highlight the value of diversity, developing relationships, and building trust among peers (Selzer et al., 2017). These leaders may act by developing and implementing assessment programs based on the Opportunities to Learn standards (OTL) to promote equity in their institutions (Chism & Pang, 2014). Although OTL tends to be associated with government involvement, transformational cultures in education focus in the shared values of the groups involved to create conditions that cater to the development interests of everyone in the organization.

**Overcoming Social Barriers.** In a study conducted to compare male and female Nobel Prize in science winners, researchers found that female winners, who were significantly fewer in number than male winners, tended to make more sacrifices in their personal and family lives than their male colleagues (Charyton et al., 2011). Unfortunately, the need to sacrifice more may be part of the reason why women continue to be underrepresented in CS&E. For example, Cardador (2017) noted that women who are promoted to management positions in engineering tend to suffer increased work-life tension and may inadvertently reinforce gender stereotypes associated with task-related efficacy. These stereotypes include beliefs that women are communal, and men tend to be agentic (Diaz & Lituchy, 2020).

Knowing that they are embedded in a male-centered environment seems to give women in STEM a sense of pride, which can be leveraged with the help of a good role model (Morganson et al., 2015). Several researchers (Athalye, 2009; Kim et al., 2011; Mackie, 2014; McInnes, 2009; Watts & Corrie, 2013) have noted the use of role models is consistent with transformational leadership. Thus, we believe that women involved in CS&E fields can benefit from personalized attention provided by transformational leaders around them and reduce the effects of the social barriers that affect their career choices and progress.

**Overcoming Gender-Biased Corporate Cultures.** While women continue to be underrepresented in CS&E due to stagnant or decreasing enrollment in undergraduate and graduate programs in these domains, there is still much educational organizations can do to help reduce the gender gap and promote

innovation. Psychogios (2007) noted that organizations are going through an exciting point in time when women claim a greater share of management jobs and are finding ways to meet performance expectations consistent with the needs of companies that compete in the more diverse and global markets. The author argued that this type of environment has led traditionally male occupations to become more feminine, which, in turn, changes the way business gets done.

This situation represents an opportunity for management teams that are slowly starting to develop more gender-inclusive policies across a variety of traditionally male-dominated industries. It has already been argued that innovation and creative problem solving are not necessarily gender-based, and that a more diverse work environment promotes creative thinking. Therefore, beyond simply meeting the workforce demand in CS&E, closing the gender gap in organizations that exemplify the realities of the new economy is so important. This task begins with educators sharing research on the matter with their students, which could help address outdated beliefs about CS&E fields being inherently masculine.

There is evidence that an integrative leadership approach has worked in the CS&E industry, as documented by Abdulai et al. (2012) who studied software firms in South Africa and learned that the goal of securing the appropriate human capital is better served by having managers adopt a transformational leadership approach to manage personnel. Therefore, transformational leadership beliefs and behaviors have been sufficiently documented in the literature as having a positive effect on helping individuals from diverse backgrounds work together as cohesive units to achieve superior results due to the added layers of talent available. Thus, it is appropriate to increase transformational leadership among organizational managers through the different methods that have been developed in the literature. Educators can influence this development by teaching future managers and minority students to seek out role models and engage in leader-follower relationships to help them address long-standing barriers for inclusion and development.

### **Summary of Transformational Leadership and the Gender Gap in CS&E**

Our intention in this paper is to integrate some of the ways transformational leaders can help plug the leak in the pipeline of women in broad CS&E domains. The previous pages have illustrated that there is a social and economic problem resulting from the pervasive underrepresentation of women in CS&E, which derives from the scarce representation of young women in STEM-related academic programs and a lack of concentrated effort on early intervention for STEM identity formation. We have addressed several key points that are relevant to this problem and have identified some solutions that are beginning to take place through the work of transformational leaders. Table 1 serves as a snapshot of that argument.

Table 1

*Factors that Negatively Influence Female Participation in CS&E and Proposed Solutions.*

| Barriers for Women in CS&E                                                                                                                                                  | Proposed Solutions                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Segregation of male and female students in academic environments, which favor the role of male students in STEM or CS&E fields (González & Pau, 2011; Hughes et al., 2013). | Promote the enrollment of female students in introductory CS&E courses (Master et al., 2016).<br><br>Develop teaching methods and curricula to better serve female students in CS&E academic programs (Fortenberry & Cady, 2009; Brotman & Moore, 2008, as cited in Hughes et al., 2013).<br><br>Communicate with female students interested in pursuing careers in STEM or CS&E fields to find ways to guide and support them toward academic success (Cerf & Johnson, 2016). |
| Career choice is influenced by gender-based perceptions that lead to misconceptions regarding the role of women in STEM or CS&E fields (Cerf & Johnson, 2016).              | Promote the fact that some traditionally male dominated industries and occupations are becoming more feminine (Psychogios, 2007).<br><br>Develop mentoring programs for female students interested in pursuing careers in CS&E (Charyton et al., 2011; Fann & Misa-Escalante, 2011; Lewis, 2018; Morganson, 2015).                                                                                                                                                             |
| There continues to be unsubstantiated preferences for men in STEM and CS&E fields (Reuben et al., 2014).                                                                    | Challenge the established perceptions regarding gender and performance by having female workers conduct themselves in a manner consistent with their values and capacity (Ahuja & Thatcher, 2005; Debebe, 2010; Ng & Sears, 2012).                                                                                                                                                                                                                                             |

Note: Developed by the authors.

We consider the solutions in Table 1 to be a realistic approach to address the gender gaps in CS&E, and the broader leadership problem. A required condition is to ensure that individuals exercise their critical thinking skills, and question forgone conclusions and assumptions that have been sustained through time (Zamudio et al., 2008). While we believe that the transformational leadership approach in academia, corporations, and social groups can be effective in addressing the problems of representation described throughout this paper, we do not believe that the discussion should end there. In the following section, we briefly share some general ideas for future research that in time may lead to sustained equity, eliminating gender as a variable from questions of representation and power.

**Future Research**

Educational, organizational, and social leaders are ultimately responsible for addressing the gender gap in STEM-related fields. However, more work on the part of scholars is required to better inform the decisions and practices of individuals trying to make change. We believe we adequately represented the current conversation on the issue, but there is much more we would like to know and discuss as we move forward in trying to help eliminate gender as a variable from any question of efficacy. We suggest the following areas for future research:

1. Document the results from initiatives taking place in engineering programs aimed at promoting educational transformations (Reidsema et al., 2013). Intentional efforts like these are examples of transformational leadership in action, which should yield positive results in terms of gender equity.
2. Examine the effects of action-learning, personalized, student-centered educational approaches on student learning and development in engineering programs (Stappenbelt, 2010). This approach, given its individual nature, holds the promise of minimizing gendered effects because it is based on the needs and characteristics of individual students.
3. Review the results from curricular and co-curricular changes designed to include leadership theory in engineering undergraduate programs (Kotnour et al., 2013). We believe that exposing engineering students to leadership models can help them understand their role as change agents and help close the gender gap in STEM-related fields.
4. making process of educators, organizational leaders, and policymakers (Wang & Degol, 2017). We believe it takes knowledgeable individuals to arrange data in a way that people from different fields can absorb and use to develop plans and execute them.

## Conclusion

Educators in science and engineering disciplines have taken notice of the gender imbalance described throughout this paper, which is encouraging, but awareness without action is not enough (Blair et al., 2017). Marginalized groups of young students can overcome barriers to growth by recognizing inequalities and becoming involved in activities to address them (Rapa et al., 2018). Educators can help start the process by having their students inquire, become self-aware, and take action (Boyle-Baise et al., 2007). We believe that this is taking place in schools at different levels; however, it is important for educational and organizational leaders to create environments where this kind of thinking is encouraged (Buxton, 2010; Kouzes & Posner, 2019; Zamudio et al., 2008).

We assert that leaks in the leadership pipeline for women in CS&E begin with the marginalizing experiences of young women and follow through to ongoing stereotypes that affect women's success in CS&E domains across industry and academia. Today, this historic marginalization has resulted in women being positioned as stigmatized groups with many STEM-related domains (Hughes et al., 2013), and is the core problem in a widening gender inequity in women's roles in CS&E. Ultimately this problem extends beyond a lack of inclusion of women and is an urgent diversity problem and a leadership imperative.

We explained that this marginalization may not occur consciously, but that it may be part of the way in which we approach early STEM education and identity formation, how we make gender-based assumptions and set expectations, and how we create environments that affect the success of professional women, regardless of occupation. We believe that it is through a transformational leadership approach that we may address and overcome these barriers, given the research that is available today. The basic assumption is that young women can be supported as they look through the stereotypes regarding male and female occupations, and focus on adding value to their organizations, regardless of their role.

Finally, we proposed areas for future study that focus on results of initiatives that are gender neutral, like examining the effects of immersion of leadership theory in engineering programs. Hopefully, these studies will shape the conversation to focus on outputs rather than inputs on engineering education and leadership. These studies may also serve to remove gender from the list of variables that associate with task-related or managerial efficacy in science and engineering fields.

## References

- Abdulai, M., Youngsun, K., & Junghoon, M. (2012). Intellectual capital and firm performance: An empirical study of software firms in West Africa. *African Journal of Information Systems*, 4(1), 1-30.
- Agarwal, S., Mittal, N., Katyal, R., Sureka, A., & Correa, D. (2016). Women in computer science research: What is the bibliography data telling us? *ACM SIGCAS Computers and Society*, 46(1), 7-19.  
<https://doi.org/10.1145/2908216.2908218>
- Aguinis, H., Ji, Y. H., & Joo, H. (2018). Gender productivity gap among star performers in STEM and other scientific fields. *Journal of Applied Psychology*. Advance online publication. <https://doi.org/10.1037/apl0000331>
- Ahuja, M. (2002). Women in the information technology profession: A literature review, synthesis, and research agenda. *European Journal of Information Systems*, 11(1), 20-34.
- Ahuja, M. K., & Thatcher, J. B. (2005). Moving beyond intentions and toward the theory of trying: Effects of work environment and gender on post-adoption information technology use. *MIS Quarterly*, 29(3), 427-459.
- American Association of University Women. (2009). Separated by sex: Title IX and single-sex education (position paper). Washington, DC: AAUW Public Policy and Government Relations Department. Retrieved from <http://www.aauw.org/files/2013/02/position-on-single-sex-education-112.pdf>. Accessed on 2 June 2016.
- Athalye, R. (2009). Transformational leadership through role models: How B-schools can teach new paradigms of leadership. *SIES Journal of Management*, 6(2), 1-10.
- Barker, L. (2009). Student and faculty perceptions of undergraduate research experience in computing. *ACM Transactions on Computing Education (TOCE)*, 9(1), 5.
- Bass, B. M. (1985). *Leadership and performance beyond expectations*. New York: Free Press.
- Blair, E. E., Miller, R. B., Ong, M., & Zastavker, Y. V. (2017). Undergraduate STEM instructors' teacher identities and discourses on student gender expression and equity. *Journal of Engineering Education*, 106(1), 14-43.  
<https://doi.org/10.1002/jee.20157>
- Bottia, M., Stearns, E., Mickelson, R., Moller, S., & Valentino, L. (2015). Growing the roots of STEM majors: Female math and science high school faculty and the participation of students in STEM. *Economics of Education Review*, 45(2015), 14-27.
- Boyle-Baise, M., Bridgwaters, B., & Brinson, L. (2007). Improving the human condition: Leadership for justice-oriented service-learning. *Equity & Excellence in Education*, 40(2), 113-122.  
<https://doi.org/10.1080/10665680601152808>
- Bureau of Labor Statistics. (2015). *College enrollment and work activity of 2014 High School graduates* [Press release], <http://www.bls.gov/news.release/hsgsec.nr0.htm>.
- Burns (2010). *Leadership*. New York, NY, Harper Perennial Political Classics.
- Buxton, C. A. (2010). Social problem solving through science: An approach to critical, place-based, science teaching and learning. *Equity & Excellence in Education*, 43(1), 120-133. <https://doi.org/10.1080/10665680903408932>
- Cardador, M. T. (2017). Promoted up but also out? The unintended consequences of increasing women's representation in managerial roles in engineering.

- Organization Science*, 28(4), 597-617.  
<https://doi.org/10.1287/orsc.2017.1132>
- Cavero, J. M., Vela, B., Cáceres, P., Cuesta, C., & Sierra-Alonso, A. (2015). The evolution of female authorship in computing research. *Scientometrics*, 103(1), 85-100.
- Cerf, V. G., & Johnson, M. (2016). Enrollments explode! But diversity students are leaving. *Communications of the ACM*, 59(4), 7. <https://doi.org/10.1145/2898431>
- Charyton, C., Elliott, J. O., Rahman, M. A., Woodward, J. L., & De Dios, S. (2011). Gender and Science: Women Nobel laureates. *Journal of Creative Behavior*, 45(3), 203-214.
- Chism, B., & Pang, V. O. (2014). Transforming education and supporting equity through opportunity to learn standards. *National Forum of Applied Educational Research Journal*, 27(1/2), 19-30.
- Cohoon, J. M., Nigai, S., & Kaye, J. J. (2011). Gender and computing conference papers. *Communications of the ACM*, 54(8), 72-80.
- Corbett, C., & Hill, C. (2015). *Solving the equation: The variables for women's success in engineering and computing*. Washington, DC: AAUW.
- Debebe, G. (2010). Creating a safe environment for women's leadership transformation. *Academy of Management Annual Meeting Proceedings*, 1-6.  
<https://doi.org/10.5465/AMBPP.2010.54501114>
- Díaz, E. R., & Lituchy, T. R. (2020). Leader behavior expectations from a gender perspective: An extension of the LEAD study in Mexico. *Revista del Centro de Investigación de la Universidad La Salle*, 13(52), 91-110.  
<https://doi.org/10.26457/recein.v13i52.2459>
- Díaz, E. R., Sánchez-Vélez, C. G., & Santana-Serrano, L. (2019). Integrating the Five Practices of Exemplary Leadership model into entrepreneurship education. *International Journal for the Scholarship of Teaching and Learning*, 13(3).  
<https://doi.org/10.20429/ijstol.2019.130310>
- Dimitriadi, A. (2013). Young women in science and technology: The importance of choice. *Journal of Innovation and Entrepreneurship*, 2(5).
- Dockterman, E. (2014). Cracking the girl code. *Time*, 184(6), 44-46.
- Ehrlinger, J., Plant, E. A., Hartwig, M. K., Vossen, J. J., Columb, C. J., & Brewer, L. E. (2018). Do gender differences in perceived prototypical computer scientists and engineers contribute to gender gaps in computer science and engineering? *Sex Roles*, 78(1-2), 40-51.  
<https://doi.org/10.1007/s11199-017-0763-x>
- Fortenberry, N. L., & Cady, E. (2009, July). Working directly with engineering departments to increase diversity. *Journal of STEM Education: Innovations & Research*, pp. 6-8.
- Gailliard, B., & Batmanian, N. (2016). The marginalization experiences of women in STEM. *Proceedings from Rutgers Scholarship on Diversity and Inclusion: Current Findings and Future Considerations*. Newark, NJ: Rutgers University.
- González, O. T., & Pau, B. (2011). "Techo de cristal" y "suelo pegajoso". La situación de la mujer en los sistemas alemán y español de ciencia y tecnología. *Revista Iberoamericana de Ciencia, Tecnología y Sociedad*, 6(18), 1-23.
- Guiso, L., Monte, F., Sapienza, P., & Zingales, L. (2008). Culture, math, and gender. *Science*, 321(5888)1164-1165.
- Hill, C., Corbett, C., & St. Rose, A. (2010). *Why so few? Women in science, technology, engineering, and mathematics*. Washington, D.C.: American Association of University Women.
- Hughes, R., Nzekwe, B., & Molyneaux, K. (2013). The single sex debate for girls in science: A comparison between two informal science programs on middle school students' STEM identity formation. *Research in Science Education*, 43(5), 1979-2007.
- Hyde, J., Lindberg, S., Linn, M., Ellis, A., & Williams, C. (2008). Diversity, gender similarities characterize math performance. *Science*, 321(5888), 494-495.
- Jesse, J. K. (2006). The poverty of the pipeline metaphor: The AAAS/CPST study on nontraditional pathways in IT/CS education and the workforce. In *Women and information technology: Research on underrepresentation*, J. M. Cohoon and W. Aspray, Eds. Cambridge, MA: The MIT Press.
- Kim, K., Fann, A., & Misa-Escalante, K. (2011). Engaging women in computer science and engineering: Promising practices for promoting gender equity in undergraduate research experience. *ACM Transactions on Computing Education*, 11(2), 1-19.
- Kotnour, T., Hoekstra, R., Reilly, C., Knight, R., & Selter, J. (2013). Infusing leadership education in the undergraduate engineering experience: A framework from UCF's eli2. *Journal of Leadership Studies*, 7(4), 48-57.  
<https://doi.org/10.1002/jls.21310>
- Kouzes, J. M., & Posner, B. Z. (2019). *Leadership in higher education: Practices that make a difference*. Oakland, California: Berrett-Koehler Publishers, Inc.
- Lewis, K. (2018). Gender-gaps, gender-based social norms, and conditioning from the vantage point of leadership theories. *International Forum of Teaching & Studies*, 14(1), 17-25.
- MacKie, D. (2014). The effectiveness of strength-based executive coaching in enhancing full range leadership development: A controlled study. *Consulting Psychology Journal: Practice and Research*, 66(2), 118-137.  
<https://doi.org/10.1037/cpb0000005>
- Margolis, J., & Fisher, A. (2002). *Unlocking the clubhouse: Women in computing*. Cambridge, MA: MIT Press.
- Master, A., Cheryan, S., & Meltzoff, A. N. (2016). Computing whether she belongs: Stereotypes undermine girls' interest and sense of belonging in computer science. *Journal of Educational Psychology*, 108(3), 424-437.  
<https://doi.org/10.1037/edu0000061>

- McKinney, V., Wilson, D., Brooks, N., O'Leary-Kelly, A., & Hardgrave, B. (2008). Women and men in the IT profession. *Communications of the ACM*, 51(2), 81-84.
- McInnes, K. (2009). Student paper: The evolution of leadership and mentorship from 1975 - Present. *Integral Leadership Review*, 9(4), 1-23.
- Morganson, V. J., Major, D. A., Streets, V. N., Litano, M. L., & Myers, D. P. (2015). Using embeddedness theory to understand and promote persistence in STEM majors. *Career Development Quarterly*, 63(4), 348-362. <https://doi.org/10.1002/cdq.12033>
- Ng, E., & Sears, G. (2012). CEO leadership styles and the implementation of organizational diversity practices: Moderating effects of social values and age. *Journal of Business Ethics*, 105(1), 41-52. <https://doi.org/10.1007/s10551-011-0933-7>
- Northouse, P. G. (2016). *Leadership theory and practice* (7th ed.). New York: Sage.
- Pawley, A. L., Schimpf, C., & Nelson, L. (2016). Gender in engineering education research: A content analysis of research in JEE, 1998-2012. *Journal of Engineering Education*, 105(3), 508-528. <https://doi.org/10.1002/jee.20128>
- Psychogios, A. G. (2007). Towards the transformational leader: Addressing women's leadership style in modern business management. *Journal of Business & Society*, 20(1/2), 169-180.
- Rapa, L. J., Diemer, M. A., & Banaies, J. (2018). Critical action as a pathway to social mobility among marginalized youth. *Developmental Psychology*, 54(1), 127-137. <https://doi.org/10.1037/dev0000414>
- Reidsema, C., Hadgraft, R., Cameron, I., & King, R. (2013). Change strategies for educational transformation. *Australasian Journal of Engineering Education*, 19(2), 101-108. <https://doi.org/10.7158/D12-008.2013.19.2>
- Reuben, E., Sapienza, P., Zingales, L. (2014). How stereotypes impair women's careers in science. *Proceedings of the National Academy of Sciences in the United States*, 111(12), 4403-4408.
- Riley, T. A. (2014). Boys are like puppies, girls aim to please: How teachers' gender stereotypes may influence student placement decisions and classroom teaching. *Alberta Journal of Educational Research*, 60(1), 1-21.
- Sekaquaptewa, D. (2011). Discounting their own success: A case for the role of implicit stereotypic attribution bias in women's STEM outcomes. *Psychological Inquiry*, 22(4), 291-295. <https://doi.org/10.1080/1047840X.2011.624979>
- Selzer, R., Howton, A., & Wallace, F. (2017). Rethinking women's leadership development: Voices from the trenches. *Administrative Sciences (2076-3387)*, 7(2), 1-20. <https://doi.org/10.3390/admsci7020018>
- Shapiro, M., Grossman, D., Carter, S., Martin, K., Deyton, P., & Hammer, D. (2015). Middle school girls and the "leaky pipeline" to leadership. *Middle School Journal*, 46(5), 3-13.
- Spielhagen, F. R. (2008). Having it our way: Students speak out on single-sex classes. In F. R. Spielhagen (Ed.), *Debating single-sex education: Separate and equal* (pp. 32-46). Baltimore, MD: Rowan & Littlefield.
- Stappenbelt, B. (2010). The influence of action learning on student perception and performance. *Australasian Journal of Engineering Education*, 16(1), 1-11.
- Szelényi, K., Denson, N., & Inkelas, K. (2013). Women in STEM majors and professional outcome expectations: The role of living-learning programs and other college environments. *Research in Higher Education*, 54(8), 851-873.
- Tajlili, M. H. (2014). A framework for promoting women's career intentionality and work-life integration. *Career Development Quarterly*, 62(3), 254-267. <https://doi.org/10.1002/j.2161-0045.2014.00083.x>
- Valian, V. (1999). *Why so slow? The advancement of women*. Cambridge MA: MIT Press.
- Vela, B., Cáceres, P., & Caverio, J. M. (2012). Participation of women in software engineering publications. *Scientometrics*, 93(3), 661-679.
- Wang, M. & Degol, J. (2017). Gender gap in science, technology, engineering, and mathematics (STEM): Current knowledge, implications for practice, policy, and future directions. *Educational Psychology Review*, 29(1), 119-140. <https://doi.org/10.1007/s10648-015-9355-x>
- Watts, M., & Corrie, S. (2013). Growing the 'I' and the 'We' in transformational leadership: The LEAD, LEARN & GROW model. *Coaching Psychologist*, 9(2), 86-99.
- Zafar, B. (2013). College major choice and the gender gap. *Journal of Human Resources*, 48(3), 545-595.
- Zamudio, M., Rios, F., & Jaime, A. M. (2008). Thinking critically about difference: Analytical tools for the 21st Century. *Equity & Excellence in Education*, 41(2), 215-229. <https://doi.org/10.1080/10665680801957378>