

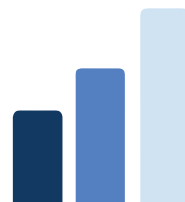
Despite the Odds: Young Women Who Persist in Engineering

EXECUTIVE SUMMARY
DECEMBER 2019

DISCOVER



LET'S MAKE A DIFFERENCE



Concord Evaluation Group



Executive Summary

There are multiple studies looking at the reasons why women leave engineering and technology paths. But what if we looked at these reports and others to identify the common factors that motivate young women to pursue — and then persist in — engineering education and careers?

DiscoverE is pleased to provide *Despite the Odds: Young Women Who Persist in Engineering*, a comprehensive literature review conducted in partnership with Concord Evaluation Group.

DiscoverE was the first organization to call to the broad engineering outreach community to make a special effort to reach girls, who are often overlooked or actively discouraged from engineering education and careers. We created Introduce a Girl to Engineering Day (Girl Day) in 2001 as a call-to-action and outreach platform to encourage girls to discover engineering.

In 2005, DiscoverE served as the collaborative hub for *Engineer Your Life*, identifying why academically capable girls were not choosing engineering, and crafting the messages they need and want as they explore their future selves. DiscoverE and partners continue to promote those messages today.

Thanks to a grant from the United Engineering Foundation, we have been able to increase our understanding of this complex issue not only through *Despite the Odds*, but also through an assessment of the value of Girl Day events to participants. This work will inform and refresh the Girl Day platform as we mark its 20th anniversary in 2021.

There is much more to do, learn, and explore. This literature review is a starting point for all of us who are working to achieve gender parity in engineering: to build on what is working; to collaborate and improve on what we can do better; to investigate unanswered questions; and, to continue the conversation about girls and women in engineering and technology.

At DiscoverE, we believe that the pathway to success lies in stakeholder inclusion and collaboration. No one solution or organization will solve the issue of gender parity. Together, we can make a difference.



Attendees at DiscoverE's Introduce a Girl to Engineering Day Capitol Hill Briefing.

Who We Are

This project represents a collaboration between DiscoverE and Concord Evaluation Group (CEG). DiscoverE's mission is to sustain and grow a dynamic engineering profession through outreach, education, celebration, and volunteerism. DiscoverE helps stakeholders expand community and educational outreach by:

- Providing resources and turnkey programs for employees and volunteers
- Supporting strong workforce diversity initiatives
- Promoting positive visibility within the engineering and technology communities, including college students and the public-at-large

Concord Evaluation Group's mission is to use its evaluation expertise to help improve learning outcomes and enhance the quality of life, especially for underserved communities. CEG has over 30 years of experience evaluating programs and initiatives in the education, engineering, and STEM space.

Purpose

Over the past few decades, there has been a growing urgency in efforts to broaden participation in engineering among historically underrepresented groups, including women (National Science Foundation, 2019). Dozens, if not hundreds, of papers, articles, and scholarly works have decried and sought to explain the imbalance of men and women in the field of engineering. Despite all the challenges faced by women in engineering — the less-than-welcoming climate, unequal pay and harassment — it is remarkable that so many women persist in the field of engineering, and that so many young women even express an interest in becoming engineers.

There is abundant research on the reasons that women choose not to stay in engineering majors in college. Some comprehensive literature reviews have focused on issues related to the lack of women in engineering, and our objective here is not to reinvent the wheel. Many such reviews tend to focus on the reasons why women avoid or leave engineering pathways. As Fernando, Cohen, & Duberley (2018) recently argued, “We have considerable understanding of the obstacles that women engineers encounter and the reasons that they leave the field, but we know less about what enables them to remain (p. 479).”

We wanted to know more about these women who persisted to become engineers. Our objective in writing this paper was to summarize what the engineering education literature says about...

- 1 Why **girls choose** to pursue engineering in college, and
- 2 What factors affect whether young **women persist** in engineering.

We surveyed the peer-reviewed, scholarly research literature. We initially focused our search primarily on literature published within the past ten years, and later expanded our search to include some earlier papers that were frequently cited in the literature, as well as qualitative or unpublished studies that covered topics that were not addressed with empirical research.

We found that there is a lack of peer-reviewed, scholarly research that focuses on the factors related to (1) girls’ interests in general and (2) their interest in studying engineering specifically. Despite this, we did find several high-quality studies that explored the factors related to young people’s interest (males and females) in STEM, more generally. So, the majority of the papers summarized in this chapter focus on STEM, with just a couple focused specifically on engineering or on women.

This literature review is only a starting point. As explained at the end of this executive summary, there are several gaps in the literature that need to be filled so we can develop a better understanding of why young women choose engineering and why they persist in the area of study in college. Doing so may enable us to better support young women and entice them to consider engineering as a viable and attractive future pathway.



Key Factors

Recent studies have identified numerous factors that have been linked to whether young women choose engineering and/or whether they persist in engineering. We’ve collapsed them into several key factors and defined them below.

Young women who choose engineering and/or persist in engineering...

- **Demonstrate an interest in and positive attitudes about engineering** – Holding favorable views of engineers and seeing the field in a positive light.
- **See value in the field of engineering** – Believing that engineers work to solve important problems and that becoming an engineer can enable them to contribute to society and help people.
- **Demonstrate engineering-related self-efficacy** – Believing, with confidence, that they have the skills and knowledge to do the work of engineers.

- **Embrace a STEM identity** – Embracing the idea that they are, or will someday become, engineers or other STEM professionals... for example, an engineer is “who I am.”
- **Have a strong support network** – Having the support of friends, family, peers, and/or role models.
- **Draw upon social and cultural capital** – Having the ability to draw strength from personal or cultural experiences of struggle to overcome obstacles.
- **Feel a sense of belonging** – Feeling as if one has found a place where they belong in the community of engineers/engineer students.

The table below summarizes the factors that we identified in the recent literature as being relevant to young women choosing engineering and/or persisting in engineering:

	Interest & Attitudes	Value	Self-Efficacy	STEM Identity	Support Networks	Social Capital	Belonging
Girls Choosing	✓	~	~	✓	✓		
Women Persisting	*		✓	~	✓	~	~

- ✓ Strong empirical evidence from the literature
- ~ Emerging evidence with some gaps in the literature, suggesting a need for more empirical research
- * Implied (i.e., although there is no empirical evidence per se, the connection between this factor and choice or persistence is implied. In this case, it’s implied that women stay in fields they are interested in)

As this table makes clear, there are separate but overlapping factors that influence young women’s decision to choose engineering as an area to study, and their determination to persist in the field during undergraduate study and early in their careers. To address these distinct sets of factors in this review, we have summarized relevant findings under the headings of “Choosing engineering” and “Persisting in engineering.”



Girl Day role models and participants at the 2019 Lipstick Engineering Lab Camp in Woodstock, GA.

INTERESTS AND ATTITUDES

Girls who choose engineering hold favorable views of engineers and see the field in a positive light.

Choosing engineering

Researchers have demonstrated a connection between early interest in STEM (as early as middle school) and subsequent choices to major in STEM in college. Maltese and Tai (2011) found that, as early as 8th grade, students who indicate an interest in STEM are highly likely to earn an undergraduate degree in a STEM field. Sadler et al. (2012) found that the key factor predicting STEM career interest at the end of high school was interest at the start of high school.

Maltese (2008) examined how high school course-taking influenced students' decisions about college majors and their pursuit of degrees, and found that academic performance differences did not appear to have an influence on students' persistence. The most important factor related to STEM persistence was positive attitude.

And how do middle schoolers develop an interest in STEM? Aschbacher, Ing, & Tsai (2014) found that girls in 7th, 8th, and 9th grades who were highly interested in science and engineering careers were more likely to have participated in formal and informal science and engineering experiences (e.g., enrichment classes, science club) before 7th grade than those who were not interested in science and engineering.



Girls at an Introduce a Girl to Engineering Day event hosted by the Society of Women Engineers chapter at Colorado State University.

VALUE

Young women who choose or persist in engineering believe that engineers work to solve important problems and that becoming an engineer can enable them to contribute to society and help people.

Choosing engineering

Some research has focused on the relationship between attainment value, utility value, and STEM persistence. *Attainment value* is the importance students attach to a choice as it relates to their conception of identity and ideals, or their competence in a given domain (Wigfield,

1994). *STEM utility value* is the importance students assign to a choice because it is relevant or useful to a student's pursuit of a current or future goal. Andersen & Ward (2014) analyzed the HSLS:09 data to look at the STEM persistence plans for 9th grade, high-ability students. They found that 9th-grade, high-ability students who have a higher attainment value for science are more likely to plan to persist in STEM.

Numerous evaluations have found that out-of-school time programs like *Future City*, *Dream Big*, and *Invent It. Build It.* can help students make connections between their own values (e.g., wanting to help people) and the work done by engineers (Paulsen & Carroll, 2019; Paulsen, 2018). However, more empirical research is needed in this area to definitively link values with the choice to pursue engineering.

SELF-EFFICACY

Young women who choose or persist in engineering believe, with confidence, that they have the skills and knowledge to do the work of engineers.

Choosing engineering

Buontempo et al. (2017) conducted a study to see which factors influenced engineering identity ("I see myself as an engineering person"). The study found that self-efficacy was one of several significant predictors of engineering identity. Young and Young (2018) conducted a study that focused on African-American females and the factors that contributed to whether they enrolled in the advanced courses necessary for pursuing engineering degrees in college. The study found that self-efficacy was a positive predictor of enrollment in advanced high school science courses for African-American females. The relationship between self-efficacy and the choice to study engineering in college is an area that is ripe for more research.

Persisting in engineering

There is strong evidence of the relationship between self-efficacy and persistence in engineering at the college level. For example, Marra et al. (2013) found that high self-efficacy was related to women students' plans to persist in engineering. Likewise, a Cole and Espinoza (2011) study found that women who reported high self-efficacy were more likely to report having such goals as pursuing a STEM career or attending graduate school. A study conducted by Naphan (2016) exploring young women's persistence in engineering programs also found that self-efficacy was the most important factor in predicting women's persistence in the program.

Some studies point to the importance of different types of self-efficacy for retention. Raelin (2014) found that academic self-efficacy was significantly

related to retention in college engineering programs. Work self-efficacy (tied to students' participation in co-op programs) was also an important factor in retention. The study found that higher retention was positively correlated with the number of co-ops taken by students. Related to work self-efficacy is the concept of role confidence. Cech (2011) found that if women develop more confidence about their abilities to be successful professionals and express less ambiguity about their fit or comfort within the discipline, then they remain in engineering at higher rates than expected.

STEM IDENTITY

Young women who choose or persist in engineering embrace the idea that they are or will someday be engineers or other STEM professionals...believing that an engineer is "who I am."

Choosing engineering

As explained by Godwin and Lee (2017), engineering identity is considered a crucial indicator for educational and professional outcomes that are important in engineering education. Recent research provides evidence that young women who choose engineering pathways are likely to start seeing themselves as engineers as early as middle or high school. Godwin found that identifying with math and physics upon entrance to college predicted engineering choice (for both men and women). Godwin argues that by "fostering the development of these subject-related identities prior to college enrollment and early in students' college careers, more students may be recruited and retained in engineering (p. 332)." Young and Young (2018) found that science identity had the highest correlation with advanced science coursework, and that science identity was a positive predictor of enrollment in advanced high school science courses for African-American females.

Persisting in engineering

The relationship between STEM identity and persistence is an area that needs more exploration at the college level. There is some evidence of a connection. For example, Gregory (2015) found six keys to the persistence of a group of female African-American engineering students: "(a) active involvement with the Black community on campus; (b) a strong desire to give back and inspire the next generation of engineers; (c) faith, family, and community; (d) a firm identity/strong sense of self; (e) being proud/passionate/committed to being an engineer; and (f) being advocates for themselves (p. v)." More research is needed to explore this topic further.

SUPPORT NETWORKS

Young women who choose or persist in engineering tend to have strong support networks of friends, family, peers, and/or role models.

Choosing engineering

A number of studies describe the importance of parental influence on high schoolers' interests and plans for college. Sahin et al. (2018) found that the students who were most likely to choose a STEM major in college were also most likely to be students with high parent encouragement. Kim et al. (2017) found that parents' expectations, their level of participation in their children's schools, and their own STEM engagement were all positively related to students' postsecondary enrollment. The authors contend that parents play a critical role in their children's academic and postsecondary outcomes. Based on their own research, Rozek et al. (2017) argue that parents are an important resource that can be engaged to increase motivation and promote important student outcomes.

Persisting in engineering

A study by Dasgupta et al. (2015) found that female engineering students who were provided with female mentors early in their college careers formed connections with the mentors, cementing, in effect, the young women's "sense of belonging." Fully 100% of the students provided with female mentors stayed in their engineering courses, while 89% of female students without mentors and only 82% of students with male mentors remained.

Dennehy and Dasgupta (2017) again looked at the impact of female mentors on female STEM students. The study found that female peer mentoring during the transition to college was effective at increasing belonging, confidence, motivation, and ultimately retention of women in engineering.

Some researchers have found that a student's mentors or role models do not necessarily have to be faculty (Lourens, 2014; Griffith, 2010). Griffith (2010) found that the existence of a higher percentage of female STEM field graduate students positively impacted the persistence of female undergraduate students in STEM majors.

According to Ong (2011), family and community support is the most salient factor that women of color identify as fostering their completion of a STEM degree.

Trenor et al. (2008) looked at persistence and retention. They found that within an already-diverse environment, where racial barriers have been essentially mitigated, students of all ethnicities in fact do experience strong social support and weakened barriers. They also found that parents and role models played a significant role in female students' selection of and persistence in engineering programs.



Participants at Ochsner Educational Outreach's Introduce a Girl to Engineering Day program in New Orleans.

SOCIAL CAPITAL

Young women who persist in engineering are often able to draw strength from personal or cultural experiences of struggle to overcome obstacles.

Persisting in engineering

There is emerging evidence from small, qualitative studies that there is a relationship between social capital and persistence. Agbenyega (2018) explored the persistence of Latina women all the way from their undergraduate experiences, through attaining their engineering degree, to their early

workplace experiences. She found that Latinas attending institutions in the US drew upon multiple forms of social and cultural capital to overcome obstacles related to being female and non-white in a male-dominated field. She also found that women in the study drew “strength from personal or inherited experience of struggle along their trajectories through engineering. They face(d) challenges with an awareness that obstacles are part of any journey and developed both an ability to transform obstacles into inspiration for working harder and an understanding that overcoming them is crucial both to repaying the debt of sacrifice of those who came before and paving the way for those who will come after (pp. ii-iii).” This is an area that needs more empirical research.



Girls from Future City's Iowa region make last minute fixes to their model before presenting at the Finals in Washington, DC.

BELONGING

Young women who persist in engineering report feeling as if they have found a place where they belong in the community of engineers/engineer students.

Persisting in engineering

Most of the empirical research connecting a sense of belonging to persistence is from the workplace. Ayre et al. (2013) found that in workplaces where there was an unusually high retention rate for female engineers, all the women revealed that they had come into the field strongly believing

in themselves as engineers. The authors found that “the most striking features of the interviews were the confidence with which all the women asserted that they were good engineers, and that they belonged in engineering, although for some women it had taken time to feel they belonged (pp. 25-26).” Corbett and Hill (2015) argue that a sense of belonging is key to retention in any given field of study. There is a need for additional evidence from college-age populations.

The focus of this work was on young women, but many of these factors also are correlated with young men's decisions to choose engineering or persist in engineering programs.

Opportunities for Impact

One theme underlying all of the research on girls’ engineering interests, attitudes, self-confidence, value perception, and experiences was that these factors were likely sparked by participating in informal learning experiences such as clubs and enrichment activities or by the opportunity to take engineering-related coursework in school.

The current research on STEM provides strong evidence that young people who develop an interest before college are likely to persist in STEM in college. The literature also indicates that once young women decide they are interested in pursuing an engineering pathway, they are as persistent,

if not more so, than young men. Although early interest leads to persistence, the window of opportunity to get young women excited about STEM does not close when they first set foot on campus; many young women switch into STEM majors while they are in college.

Thus, there are many opportunity windows during a young woman’s life in which interventions and programming can have a significant impact on her choices and persistence. Below is a table that summarizes some of the most obvious opportunities to encourage young women to choose and persist in the field of engineering.

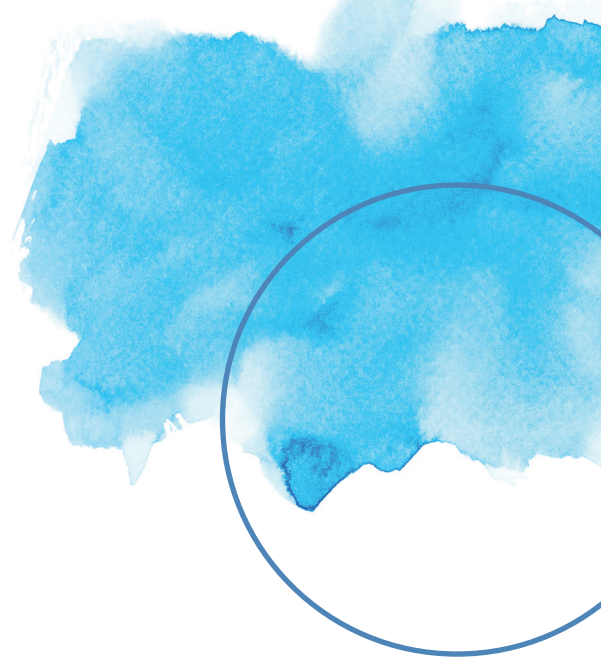
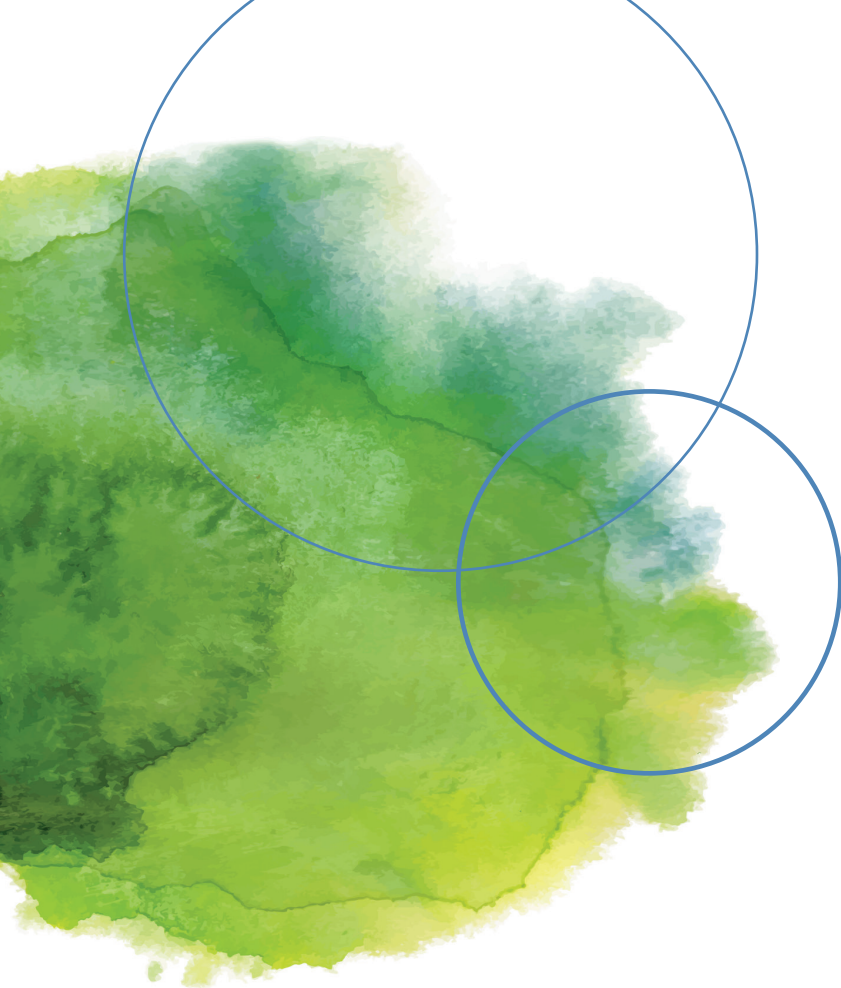
	Interest & Attitudes	Value	Self-Efficacy	STEM Identity	Support Networks	Social Capital	Belonging
Role Models	✓	✓	✓	✓	✓	✓	✓
Effective Messages	✓	✓	✓	✓		✓	✓
Engineering Activities	✓	✓	✓	✓	✓		✓
Student-Centered Learning	✓	✓	✓	✓	✓		✓

For example, engineer role models, effective messaging campaigns, hands-on engineering activities, and student-centered learning opportunities can:

- Spark girls’ interest or shift their attitudes about the field,
- Show girls how consistent the field is with the things they value the most,
- Encourage girls and build their confidence, and
- Help them to see themselves as engineers.

Likewise, role models can also help young women feel a sense of belonging and being supported, and can help them understand how to tap into and use their own sources of social capital. Effective messages can be deployed to help young women learn how to tap into their own social capital and to teach them they belong in the field.

Finally, engineering activities and student-centered learning can provide girls with the chance to develop an interest in engineering, build their confidence in their problem-solving abilities, and create a STEM identity.



Future Areas of Inquiry

This literature review is only a starting point. There are several gaps in the literature that need to be filled so we can develop a better understanding of why young women choose engineering and why they persist in college. Doing so may enable us to better support young women and entice them to consider engineering as a viable and attractive future pathway.

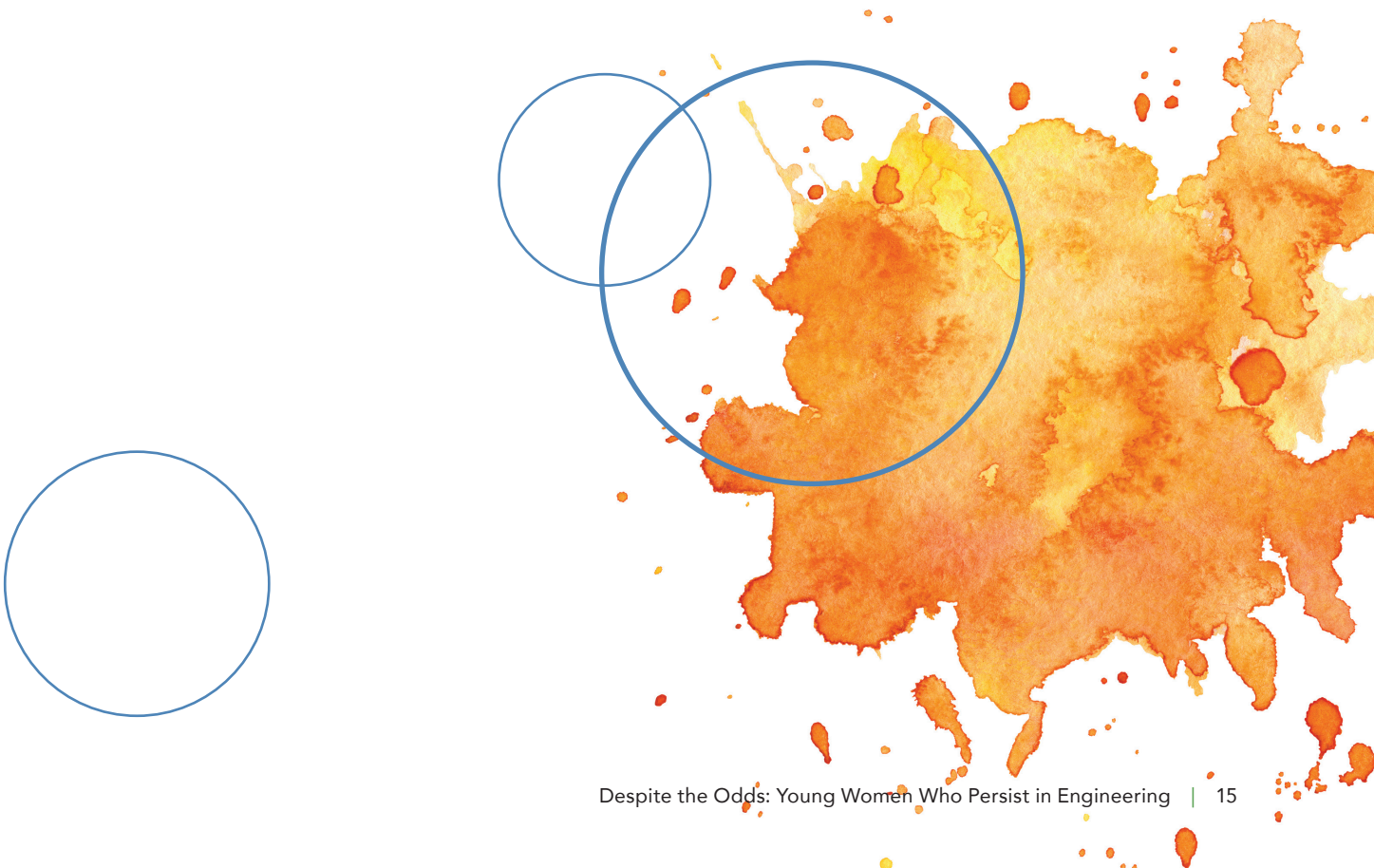
For instance, we need more experimental evidence that can be extrapolated to the national population of young women. As Cheryan (2017) argues, “There are numerous interventions currently underway to motivate more girls and women to enter and remain in STEM fields. More of these efforts should be conducted in a scientific manner and made widely known so that their successes can be evaluated, documented, and disseminated (p. 24).”

An obvious starting point is a call for researchers to continue using national databases, such as those available from the National Center for Education Statistics, to explore engineering specifically, rather than STEM more generally.

Another area ripe for investigation is the exploration of whether the factors that enable young women to stay on engineering pathways are different for women of different races, ethnicities, sexual orientations, gender identities, and socioeconomic classes. While we found a number of informative qualitative studies, there simply aren’t enough empirical studies that can help us answer these questions.



Presenters at DiscoverE's Introduce a Girl to Engineering Day Capitol Hill Briefing.





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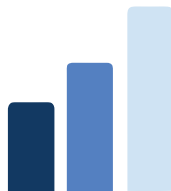


LET'S MAKE A DIFFERENCE

DiscoverE

1420 King Street,
Alexandria, VA 22314
Info@DiscoverE.org

DiscoverE.org



Concord Evaluation Group

Christine Andrews Paulsen, Ph.D.

Concord Evaluation Group

PO Box 1205,
Concord, MA 01742
christine@concordevaluation.com

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