Examining the Experiences of Women and Underrepresented Students Who Leave Engineering Undergraduate Programs

Dr. Chrystal A. S. Smith, National Science Foundation

Chrystal A. S. Smith, Ph.D., is a cultural anthropologist with expertise in diversity, equity, and inclusion in STEM education. Her research uses social science theoretical frameworks to examine how implicit factors such as culture and social capital influence the persistence of students belonging to groups historically underrepresented in STEM education. Currently, she is a Program Officer in the Division of Equity for Excellence in STEM, Directorate for STEM Education, National Science Foundation.

John Skvoretz Jr., University of Florida

John Skvoretz is Distinguished University Professor in the Department of Sociology & Interdisciplinary Social Sciences and, by courtesy, Distinguished University Professor in the Department of Computer Science and Engineering at the University of South Florida. A Fellow of the American Association for the Advancement of Science and a recipient of the James Coleman Distinguished Career Award from the Mathematical Sociology Section of the American Sociological Association, his current research projects analyze social network data from various sources.

Dr. Rebecca Campbell-Montalvo, University of Connecticut

Dr. Rebecca Campbell-Montalvo is a cultural anthropologist who focuses on understanding how a range of people (including women, historically excluded racial/ethnic groups, and LGBTQIA+ students) are served in undergraduate STEM contexts, with an emphasis on engineering and biology. She is a postdoctoral research associate in the Neag School of Education in the Department of Curriculum and Instruction at the University of Connecticut. In addition, Campbell-Montalvo is Co-PI on a $500,000 NSF grant that seeks to improve inclusion in biology education and biology education research through the Inclusive Environments and Metrics in Biology Education and Research network. Prior to her current role, Dr. Campbell-Montalvo was the Program Assistant for the National Institute of Health's Maximizing Access to Research Careers Undergraduate Student Training in Academic Research program in the Department of Chemical and Biomedical Engineering at the University of South Florida.

Dr. Ellen Puccia, Beta Research Associates

Ellen Puccia, Ph.D., is an applied anthropologist with expertise in mixed methods data collection and analysis. In addition to her work in healthcare access, she also focuses on diversity, equity, and inclusion in STEM education. Specifically, she looks at the influence of social capital on the persistence of underrepresented groups in STEM. Currently, she is the owner and Executive Director of Beta Research Associates, Inc.

Dr. Gladis Kersaint, University of Connecticut

Gladis Kersaint, Ph.D., is a Professor of Mathematics Education and Associate Dean at the University of South Florida's College of Education. She is the principal investigator of several grants including the NSF- funded study, "The Effects of Social Capital and Cultural Models on the Retention and Degree Attainment of Women and Minority Engineering Undergraduates." Her areas of professional interests include factors that influence STEM education, mathematics teaching, and learning of at-risk students, and use of technology for learning and teaching mathematics. She received her doctorate in mathematics education from Illinois State University and her Masters degree in Education and bachelors degree mathematics from the University of Miami.

Dr. Julie P. Martin, The Ohio State University

Julie P. Martin is the Assistant Vice President for Research and Team Talent Development in the Office of Knowledge Enterprise at The Ohio State University. Julie is a Fellow of ASEE and the editor-in-chief of Journal of Women and Minorities in Science and Engineering.

Dr. Hesborn Wao

Hesborn Wao, Ph.D., conducts research that uses mixed methods approaches to investigate the implicit factors associated with the under representation of women and minorities in STEM education. He strives to improve K-20 STEM learning experiences and degree attainment. He received his Ph.D. in Measurement & Evaluation and M.Ed. in Curriculum & Instruction both from the University of South Florida, and his B. Ed in Mathematics from the University of Nairobi, Kenya.

Examining the Experiences of Women and Underrepresented Minority Students Who Leave Engineering Undergraduate Programs

Introduction

Women and underrepresented minority (URM) students are lower percentages of scientists and engineers than they are in the national population [53]. A meaningful way to broaden participation in science, technology, engineering, and mathematics (STEM) is to uncover why women and URM students who declare engineering majors may leave engineering prior to graduation. To increase our understanding of why women and URM students may leave engineering undergraduate programs at higher rates than students from other groups, we examine how social capital and cultural models of engineering success (CMES) contribute to their persistence and degree attainment. Social capital refers to students' social connections and the resources available through those connections. CMES refer to beliefs about how to succeed in an engineering program (i.e., degree attainment).

In this paper, we present findings from a National Science Foundation (NSF) funded study which hypothesizes that women and URM students who persist in engineering programs are more likely to 1) enter with and acquire/develop various forms/levels of the social capital and 2) resolve conflicts between their CMES and the culture espoused by the program. The research question we address in this paper is: Why do women and URM students switch from engineering undergraduate majors to non-engineering majors?

Theoretical Frameworks

We are guided by social capital and cultural model frameworks to gain an understanding of the social, cultural, and cognitive factors that impact the retention and degree attainment of women and minorities in engineering. Supported by the highly disproportionate graduation rates of URM undergraduate and doctoral students in STEM disciplines at historically black colleges and universities (HBCU) and Hispanic-serving institutions (HSI) [52, 55], and the lower rates of STEM major declaration by women, numerous studies suggest that while academic preparation and socio-economic status are contributing factors, the low numbers of under-represented undergraduate groups in STEM are likely due to implicit factors unrelated to aptitude and interest [1, 4, 38, 44, 59, 60, 62, 63, 71]. To understand these factors, including social connections and the environment, STEM education researchers are increasingly studying social capital [16, 17, 24, 30, 46, 75, 77] and culture [6, 27, 33, 68, 73, 74].

Social Capital Theory. Since Bourdieu [14] proposed social capital as "connections" or access to a well-established network of useful relationships (e.g., who people know) and material resources (e.g., program information) that benefit group members, debate about its conceptualization continues among scholars from various disciplines [2, 7, 23, 32, 40, 42, 47, 55, 57]. Yet, there is consensus that social capital benefits specific societal groups, primarily the influential majority, but not traditionally under-represented groups such as women and URM students in STEM. We adhere to Lin's [42, p. 3] conceptualization that social capital "is captured in social relations and that its capture evokes structural constraints and opportunities as well as actions and choices on the part of the actors." Women and URM students in STEM disciplines are often unaware of the "unofficial" routes and strategies to achieve success unless their advisors, faculty, and peers share this information [62, 68]. Thus, mentoring and social

connections can be consequential for their persistence [5, 63, 68]. For example, participation in professional societies such as the Society for Women Engineers, National Society of Black Engineers, and Society of Hispanic Professional Engineers not only reduces feelings of isolation, but also establishes connections that provide beneficial resources and insider knowledge for women and URM students in engineering [24, 35].

Cultural Model Theory. To gain insight into how culture influences the experiences of women and URM students in engineering, we are guided by cultural model theory. Cognitive anthropologists developed cultural model theory to understand how individuals cognitively organize and structure their perceptions of material phenomena, experiences, behavior, and environment about specific cultural domains such as education, gender, and ethnicity [25, 64]. What distinguishes a cultural model from mere general knowledge is that the beliefs, meanings, and assumptions about the cultural domain are shared to a certain degree among others in the individual's cultural group [31, 39, 50]. Cultural models are shaped by cultural experiences, parents, teachers, and peers, but are also influenced by the wider society. Consequently, cultural models are "mediating devices" that can be altered when an individual or group is exposed to different environments such as how STEM programs influence how women and URM students believe that they should act and the STEM identity they adopt to succeed. [70].

Cultural models of education include beliefs about 1) how to become a successful student, 2) how the teacher-student relationship should function, and 3) how education contributes to making an individual a better person and can vary by gender and ethnicity [31]. Students internalize the "cultural models of gender," that is, what it means to be a woman and the "culture of romance" that objectifies their sexual attractiveness and negatively stereotypes their academic aptitude in predominantly male academic programs [39, 50]. Fryberg and Markus [31] found while American Indian, Asian American, and European American university students shared beliefs about the societal value of education, each group had different cultural models of education that were associated with their cultural experiences. Women and URM entering engineering undergraduate programs may bring cultural models that conflict with their programs' set of beliefs about how students can succeed [34], which are founded upon male - dominant cultural norms. This program culture can cause women and URM students to feel a "lack of belonging" and heightened anxiety due to the fear of negative stereotyping, hyper-competitiveness, and perceived discrimination, which may increase feelings of isolation and the likelihood of switching to non-engineering majors [8, 24, 29, 44, 45, 48, 54, 58, 60, 76].

Definitions of Social Capital and CMES. We define social capital as a pool of resources available to a student from outside (e.g., parent) or from within the institution (e.g., teacher, science club) which can be accessed (e.g., through student-alter interaction) and activated to achieve success [42]. An alter is an influential person in the students' social network. Situating CMES within cultural models of education, we define CMES as the students' shared beliefs, perceptions, and attitudes about how to succeed in engineering programs [31].

Methodology

This five-year mixed methods longitudinal study followed a cohort of 2,186 engineering majors attending 11 diverse universities from the first year of their engineering undergraduate program to their fifth year to determine how social capital and CMES influence their persistence. The 11

universities included seven predominantly white institutions (PWIs), three Hispanic-serving Institutions (HSIs), and one Historically Black College/University (HBCU). Students were surveyed each year and received compensation for participating in the study. Survey one (S1) measured the social capital and CMES they brought from their high school and other pre-college experiences into their engineering programs. Survey two (S2) to survey five (S5), similar in structure, measured the social capital and CMES that students acquired while enrolled in their engineering programs. S2 to S5 included social capital survey items that asked students who were the alters (influential individuals) in their social networks that they relied on advice, insider knowledge, and mentoring and what engineering-related activities/resources such as professional engineering organizations did they use or participate in to be successful. The CMES survey items asked students about how they felt that they fit in their engineering programs, their interactions with their peers, and if they experienced a hostile atmosphere in their engineering programs which included "sexual/gender/ethnic stereotypes, comments or jokes." A full description of the recruitment of students, survey development process, and survey data collection and analysis can be found in Smith et al. [66].

All five surveys asked students if they were still enrolled in their engineering programs, if they had switched to a non-engineering major, or if they were no longer enrolled at any university/college. If the student reported that they had switched to a non-engineer major, they were asked the reason(s) why, and to rank a provided list of reasons in the order of the most important to least important. The reasons why students left engineering fell into two primary categories: social capital and CMES. Students with social networks that have more social capital that they can access and activate might be more likely to be academically prepared because 1) they attend high schools offer a wide range of high-level STEM courses and STEM programs and 2) have been advised about the STEM course sequencing required pursue STEM majors [42, 75]. CMES reasons are directly related to how student experiences in their engineering program (i.e., whether they feel welcome and have positive interactions with the instructors, advisors, staff and their peers) influence their decisions to stay in or leave engineering. This paper focuses on the responses from S2 related to student enrollment status and reasons for leaving engineering because in our study this is when the largest number of students reported that they were no longer engineering majors. Tables with the gender and racial/ethnic characteristics of the students who responded to S1 to S5 and the number of students who reported that they left engineering in S1 to S5 can be found in Smith et al. [66].

To gather rich data about students' experiences in their engineering programs, we interviewed a subsample of 55 women and URM students who responded to S1. The interview questions asked about the social capital and CMES that students had brought into their engineering programs along with the social capital and CMES that students had acquired so far. Specific questions addressed who respondents relied on for information, advice, and support (i.e., social capital) and what it takes to be a successful high school and a successful engineering student. Other questions asked whether or not they fit in their departments and if they were similar to other students (i.e., CMES). In year four of the study, 36 follow-up interviews were conducted with the same sample of students (nine were lost to attrition). Besides being asked about the social capital and CMES they had acquired and their experiences in their engineering programs, they were asked about their enrollment status. If they reported that they had left engineering, we asked if they had switched to another major or left university and the reasons why. A codebook developed by the

qualitative experts on the research team was used to code the interview transcripts for themes related to social capital, CMES, and persistence (i.e., leaving engineering). A full description of the recruitment of students, interview protocol development process, and interview data collection, development of the codebook, coding and inter-rater reliability, and thematic analysis can be found in Puccia et al. [56].

Findings

A total of 1,754 students responded to S2, and 249 of those students reported that they had left their engineering majors (henceforth referred to as "leavers"). We found that, in comparison to the broader sample (see Skvoretz et al. [65]), men (72% of sample, 68% of leavers) were slightly overrepresented amongst leavers in comparison to women (28% of sample, 32% of leavers). At the same time, white (49% of sample, 54% of leavers) and Black students (6% of sample, 10% of leavers) were overrepresented amongst leavers, while Latinx student leavers (24% of sample, 24% of leavers) mirror their representation in the broader sample, and Asian (16% of sample, 11% of leavers) and other students (5% of sample, 1% of leavers) were underrepresented amongst leavers. Longstanding trends in graduation rates have shown that fewer women and URM students declare and obtain degrees in engineering, though women have been obtaining degrees at higher rates than their declaration.

The majority of the students who left engineering had switched to non-engineering majors, primarily business, management, marketing, and related support services, followed by the social sciences, computer and information sciences and support services, and the physical and biological sciences and biomedical sciences. Table 1 shows the gender and race/ethnicity of the students who reported leaving engineering.

Table 1
Gender and Race/Ethnicity of Students Who Left Engineering Undergraduate Programs

Leavers	**Asian n (%)**	**Black n (%)**	**Latinx n (%)**	**White n (%)**	**Other n (%)**	**Total n (%)**
Men	10 (63)	14 (58)	38 (64)	92 (68)	1 (20)	155 (72)
Women	17 (37)	10 (42)	21 (36)	42 (32)	4 (80)	94 (28)
Total	**27 (11)**	**24 (10)**	**59 (24)**	**134 (54)**	**5 (1)**	**249 (100)**

Reasons for Leaving Engineering

The reasons why students left engineering fell into two primary categories related to social capital (1, 2, 3, 4, 5, 6, 7, 8, 12, 13, 14) and CMES (9, 10, 11) (see Table 2). Of all the reasons listed, students selected, "I was academically prepared, but am no longer interested in pursuing engineering" as the most frequent reason and the highest ranked reason that they are no longer enrolled in their engineering undergraduate programs. Students who entered their engineering program academically prepared are likely to have higher social capital i.e., stronger social networks more resources that lead them to persist. Table 2 shows the rank of reasons that students selected for leaving engineering on survey 2.

Table 2
Survey 2: *Ranked Reasons Students Left Engineering Undergraduate Programs:*

Rank	Reasons
1	I was academically prepared, but am no longer interested in pursuing engineering.
2	I entered my engineering program not knowing what to expect from my engineering coursework.
3	I entered my engineering program not understanding what it meant to be an engineer.
4	I was not academically prepared for the math courses in my engineering program.
5	I was not academically prepared for the chemistry courses in my engineering program.
6	I was not academically prepared for the physics courses in my engineering program.
7	I was concerned about my GPA declining.
8	Engineering was too competitive.
9	I did not fit in with other students in my department.
10	I was not welcome in my engineering department.
11	My department had a hostile environment.
12	I was concerned about losing my scholarship.
13	I had family obligations.
14	I had financial problems.
15	Other reasons, please specify.
16	None of the above.

**Other reasons specified included not enjoying engineering, choosing other majors that were more interesting, and that engineering was too competitive.*

Gender
Women were likely to rank the reason, "I was academically prepared, but am no longer interested in pursuing engineering" slightly higher than men were. The second most frequent reason selected and ranked similarly by both men and women was "I entered my engineering program not knowing what to expect from my engineering coursework." Ranked higher by women than men, the third most frequent reason selected was, "I entered my engineering program not understanding what it meant to be an engineer." Ranked slightly higher by men than

women, the fourth most frequently selected reason was, “I was not academically prepared for the math courses in my engineering program.”

Race/Ethnicity
Black students were overrepresented among students who selected the reasons, “I entered my engineering program not understanding what it meant to be an engineer” and “I was not academically prepared for the math courses in my engineering program.” Black students were underrepresented among students who selected the reason, “I did not fit in with other students in my department.” As suggested by our interview data, this finding does not necessarily mean Black students felt that they fit in better than other students did, but rather they might have given primacy to other issues [18].

Latinx students were overrepresented among students who selected the reason, “I did not fit in with other students in my department” and were underrepresented among students who selected the reason, “I entered my engineering program not understanding what it meant to be an engineer.”

Follow Up Interviews
Our analysis of the 36 follow-up interviews found the primary reasons that women and URM students switched to non-engineering majors was because they did not know what engineering was until they started taking courses and that they were concerned about their grade point average because of the difficulty of the coursework. The students switched also discussed issues of fit. Overall, these reasons were consistent with the reasons reported by students who responded to S2. Because of the small sample size of 36 women and URM students interviewed, the data cannot be disaggregated by gender and race/ethnicity.

Explaining how engineering what was not she had expected, a Black woman at a PWI explained why she switched from civil engineering to construction technology:

> It’s not what I wanted to do, I thought I wanted to [do it]. I thought civil engineering would be me doing construction and that’s not what it was. It was mainly working on roadways and bridges and it wasn’t what I wanted to do. And after a while the classes had me stressed out. And the teachers, I didn’t really feel like I could get help from them. And so I wasn’t enjoying it, I wasn’t enjoying the program and I wanted to do something else before it was too late.

Realizing that it was not necessarily his strength nor passion, a Black man at a PWI explained why he switched from engineering to business analytics and information systems:

> At the time I was seeing that engineering wasn’t really like my forte. I just noticed that it wasn’t what I thought I was passionate about at the time. It would become like really kind of obvious to me that when I think about it a bit more and explore my options a bit more. So that’s what I did and I came to the conclusion that the program I’m in now is a better fit for me personally.

Discussing the sheer amount of effort she had to put in to make average grades in engineering, a Latinx woman at a PWI who switched from engineering to accounting explained:

> I took my first exam in thermodynamics course and I turned in that test. I left it completely blank and I just felt really bad about myself. So I was crying the whole way home and I was like, I don't think I can do this anymore. I ended up getting like the average grade of the class. But I know, I remember I was studying for like an entire week nonstop l really going over things trying to grasp everything from the book. But like I just feel if I couldn't grasp like the first part, I may have not been able to grasp any of it all. So I didn't want to continue feeling like that and like not being rewarded for the amount of time that I was putting into it.

These students' reasons for leaving engineering are primarily related to social capital. Their social networks did not provide them with knowledge about what engineering is, advice about the course-taking sequence to be academically prepare in high school to major in engineering, and strategies to succeed in engineering courses. However, not feeling that they could go to faculty for help with their course may be indicative of the first year weed-out culture prevalent in many STEM programs.

Discussion

We found that women were likely to rank being no longer interested as their reason for leaving engineering higher than men did. When also had entered their programs with less understanding about what it meant to be an engineer. When it came to racial and ethnic group responses, Black students were also more likely to say that they entered their program not knowing what it meant to be an engineer and not being prepared for the math courses or fitting in with other students as reasons for their departure. This issue of not knowing ahead of time what it meant to be an engineer and feeling like they did not fit in was also more often reported by Latinx students. We also found that women, Black, and Latinx people were more likely to rank higher that they entered their program not knowing what to expect, and Latinx students were more likely to report not fitting in well as reasons they left.

Our findings are consistent with other studies that have found that culture and climate play an important role in women and URM students leaving engineering as does academic performance [11, 48, 78]. Our work offers important insight into potential ways that engineering participation can be broadened by isolating the reasons that women and URM students provide for leaving engineering prior to graduating with their engineering degree. In addition, our results contribute to the literature [5, 8, 18] which has demonstrated that engineering is often unwelcoming to women and URM students, which can result in their departure. Finally, we echo the applications of other work [6, 8] , which has called for engineering departments to transform their cultures and climates.

The lack of social capital (i.e., alters such as parents/guardians and teachers with knowledge about engineering and pursuing engineering as a career in their social networks) explains why so many women and URM students in our sample reported they did not know what engineering was before entering college and did not know what to expect from their engineering coursework [56]. In addition, we found that Black students entered their engineering programs with lower social

capital than other groups of students [65]. Our findings reveal the value of social capital, as alters with knowledge about engineering and pursuing engineering provide valuable insights about engineering as a career, how to prepare academically for engineering coursework, and insider knowledge about how to navigate engineering programs (e.g., which courses to take and when, joining professional engineering organizations, and joining a study group) [19, 66, 77]. Also, these alters often have similar characteristics as the students so they have insider knowledge about how to overcome obstacles [18].

Implications

Consistent with previous research, we argue that engineering (and other STEM) programs must transform their culture and become more welcoming to women and URM students in the first year of engineering programs when they are at the highest risk of switching to non-engineering majors. Engineering programs should shift their current focus which is primarily on interventions that "fix" students to interventions that change their culture and climate. For example, they should collaborate with their colleagues in education (or with organizations such as Women in Engineering Programs and Advocates Network) to train instructional staff to use inclusive teaching and pedagogy strategies in the classrooms [30]. Engineering programs should also consider restructuring particularly difficult courses such as thermodynamics so students can be more successful [6]. In addition, engineering programs should work to change how faculty and other instructional staff and advisors view student success and interact with students in their first and second years which are critical to changing the weed-out culture and will benefit all students.

Further, engineering programs should collaborate with engineering organizations (e.g., National Society of Black Engineering, Society of Women Engineers, Society of Hispanic Professional Engineers) to conduct outreach activities at local high schools and middle schools, particularly those in underserved areas. This outreach should focus on providing women and URM students in high school with in-depth understanding about what it means to be an engineer, the different types of available engineering degree options, and what they can expect when enrolled in an engineering program. The outreach activities should also provide students important information about the course sequencing necessary to academically prepare them to pursue engineering majors. Becoming familiar with the STEM courses not offered in some underserved schools which will allow engineering programs to develop strategies to fill this gap. This would provide students with the social capital (i.e., a network of resources) they need to start on the path to becoming an engineer.

Acknowledgement

This material is based upon work supported by the National Science Foundation under Award No. 1664366.

References

1. Acker, Sandra, and Grace Feuerverger. "Doing Good and Feeling Bad: The Work of Women University Teachers." *Cambridge Journal of Education*, vol. 26, no. 3, Nov. 1996, pp. 401–22. *DOI.org (Crossref)*, https://doi.org/10.1080/0305764960260309.

2. Adler, Paul S., and Seok-Woo Kwon. "Social Capital: Prospects for a New Concept." *The Academy of Management Review*, vol. 27, no. 1, Jan. 2002, p. 17. *DOI.org (Crossref)*, https://doi.org/10.2307/4134367.

3. Astin, Alexander W. *What Matters in College? Four Critical Years Revisited*. 1st ed, Jossey-Bass, 1993.

4. Astin, Alexander W., and Helen S. Astin. *Undergraduate Science Education: The Impact of Different College Environments on the Educational Pipeline in the Sciences*. Higher Education Research Institute, UCLA, 1993.

5. Atman, Cynthia, et al. "Findings From The Academic Pathways Study Of Engineering Undergraduates 2003 2008 Overview And Panel Discussion." *2009 Annual Conference & Exposition Proceedings*, ASEE Conference, 2009, p. 14.631.1-14.631.7. *DOI.org (Crossref)*, https://doi.org/10.18260/1-2--5377.

6. Baba, Marietta L., and Diane Pawlowski. "Creating Culture Change: An Ethnographic Approach to the Transformation of Engineering Education." *Proceedings of International Conference on Engineering Education*, 2001.

7. Bandiera, Oriana, et al. "Social Capital in the Workplace: Evidence on Its Formation and Consequences." *Labour Economics*, vol. 15, no. 4, Aug. 2008, pp. 724–48. *DOI.org (Crossref)*, https://doi.org/10.1016/j.labeco.2007.07.006.

8. Beasley, Maya A., and Mary J. Fisher. "Why They Leave: The Impact of Stereotype Threat on the Attrition of Women and Minorities from Science, Math and Engineering Majors." *Social Psychology of Education*, vol. 15, 2012, pp. 427–48.

9. Berger, Mark C. *Kentucky's per Capita Income: Catching up to the Rest of the Country.* Kentucky Annual Economic Report, University of Kentucky, Center for Business and Economic Research.

10. Bonous-Hammarth, Marguerite. "Pathways to Success: Affirming Opportunities for Science, Mathematics, and Engineering Majors." *The Journal of Negro Education*, vol. 69, no. 1/2, pp. 92–111.

11. Borman, Kathryn M., et al., editors. *Becoming an Engineer in Public Universities: Pathways for Women and Minorities*. 1st ed, Palgrave Macmillan, 2010.

12. Bourdieu, Pierre. *Outline of a Theory of Practice*. Cambridge University Press, 1977.

13. ---. “The Forms of Capital.” *Handbook of Theory and Research for the Sociology of Education* , Greenwood, 1986, pp. 241–58.

14. Brainard, Suzanne G., and Linda Carlin. “A Six-Year Longitudinal Study of Undergraduate Women in Engineering and Science*.” *Journal of Engineering Education*, vol. 87, no. 4, Oct. 1998, pp. 369–75. *DOI.org (Crossref)*, https://doi.org/10.1002/j.2168-9830.1998.tb00367.x.

15. Braun, Virginia, and Victoria Clarke. “Using Thematic Analysis in Psychology.” *Qualitative Research in Psychology*, vol. 3, no. 2, Jan. 2006, pp. 77–101. *DOI.org (Crossref)*, https://doi.org/10.1191/1478088706qp063oa.

16. Brawner, Catherine E., et al. “Women in Industrial Engineering: Stereotypes, Persistence, and Perspectives.” *Journal of Engineering Education*, vol. 101, no. 2, Apr. 2012, pp. 288–318. *DOI.org (Crossref)*, https://doi.org/10.1002/j.2168-9830.2012.tb00051.x.

17. Brown, S., et al. “Social Capital in Engineering Education.” *Proceedings Frontiers in Education 35th Annual Conference*, IEEE, 2005, pp. S3D-10-S3D-16. *DOI.org (Crossref)*, https://doi.org/10.1109/FIE.2005.1612269.

18. Campbell-Montalvo, Rebecca, et al. “How Stereotypes and Relationships Influence Women and Underrepresented Minority Students’ Fit in Engineering.” *Journal of Research in Science Teaching*, vol. 59, no. 4, Apr. 2022, pp. 656–92. *DOI.org (Crossref)*, https://doi.org/10.1002/tea.21740.

19. Campbell-Montalvo, Rebecca, et al. “The Influence of Professional Engineering Organizations on Women and Underrepresented Minority Students’ Fit.” *Frontiers in Education*, vol. 6, Jan. 2022, p. 755471. *DOI.org (Crossref)*, https://doi.org/10.3389/feduc.2021.755471.

20. Chanderbhan-Forde, Susan, et al. “‘The Doors Are Open’ but They Don’t Come in: Cultural Capital and the Pathway to Engineering Degrees for Women.” *Journal of Women and Minorities in Science and Engineering*, vol. 18, no. 2, 2012, pp. 179–98. *DOI.org (Crossref)*, https://doi.org/10.1615/JWomenMinorScienEng.2012004190.

21. Clifton, Rodney A. “The Education of University Students: A Social Capital Perspective.” *College Teaching*, vol. 47, no. 3, Aug. 1999, pp. 114–18. *DOI.org (Crossref)*, https://doi.org/10.1080/87567559909595798.

22. ---. “The Effects of Social Psychological Variables and Gender on the Grade Point Averages and Educational Expectations of University Students: A Case Study.” *Canadian Journal of Higher Education*, vol. 27, no. 2/3, May 2017, pp. 67–90. *DOI.org (Crossref)*, https://doi.org/10.47678/cjhe.v27i2/3.183304.

23. Coleman, James S. “Social Capital in the Creation of Human Capital.” *American Journal of Sociology*, vol. 94, Jan. 1988, pp. S95–120. *DOI.org (Crossref)*, https://doi.org/10.1086/228943.

24. Daily, Shaundra Bryant, et al. “The Development of Social Capital in Engineering Education to Improve Student Retention. .” *American Society for Engineering Education Southeast Section Conference*, 2007.

25. D’Andrade, Roy. “Moral Models in Anthropology.” *Current Anthropology*, vol. 36, no. 3, June 1995, pp. 399–408. *DOI.org (Crossref)*, https://doi.org/10.1086/204377.

26. De Graaf, Nan Dirk, et al. “Parental Cultural Capital and Educational Attainment in the Netherlands: A Refinement of the Cultural Capital Perspective.” *Sociology of Education*, vol. 73, no. 2, Apr. 2000, p. 92. *DOI.org (Crossref)*, https://doi.org/10.2307/2673239.

27. Dryburgh, Heather. “Work Hard, Play Hard: Women and Professionalization in Engineering—Adapting to the Culture.” *Gender & Society*, vol. 13, no. 5, Oct. 1999, pp. 664–82. *DOI.org (Crossref)*, https://doi.org/10.1177/089124399013005006.

28. Etcheverry, Emily, et al. “Social Capital and Educational Attainment: A Study of Undergraduates in a Faculty of Education.” *Alberta Journal of Educational Research*, vol. 47, pp. 24–39.

29. Fisher, Allan, et al. “Undergraduate Women in Computer Science: Experience, Motivation and Culture.” *Proceedings of the Twenty-Eighth SIGCSE Technical Symposium on Computer Science Education - SIGCSE ’97*, ACM Press, 1997, pp. 106–10. *DOI.org (Crossref)*, https://doi.org/10.1145/268084.268127.

30. Foor, Cynthia E., et al. “‘I Wish That I Belonged More in This Whole Engineering Group:’ Achieving Individual Diversity.” *Journal of Engineering Education*, vol. 96, no. 2, Apr. 2007, pp. 103–15. *DOI.org (Crossref)*, https://doi.org/10.1002/j.2168-9830.2007.tb00921.x.

31. Fryberg, Stephanie A., and Hazel Rose Markus. “Cultural Models of Education in American Indian, Asian American and European American Contexts.” *Social Psychology of Education*, vol. 10, no. 2, June 2007, pp. 213–46. *DOI.org (Crossref)*, https://doi.org/10.1007/s11218-007-9017-z.

32. Fukuyama, Francis. *Trust: The Social Virtues and the Creation of Prosperity*. 1. Free Press paperback ed, Free Press, 1996.

33. Godfrey, Elizabeth, and Lesley Parker. “Mapping the Cultural Landscape in Engineering Education.” *Journal of Engineering Education*, vol. 99, no. 1, Jan. 2010, pp. 5–22. *DOI.org (Crossref)*, https://doi.org/10.1002/j.2168-9830.2010.tb01038.x.

34. Goldrick-Rab, Sara. “Following Their Every Move: An Investigation of Social-Class Differences in College Pathways.” *Sociology of Education*, vol. 79, no. 1, Jan. 2006, pp. 67–79. *DOI.org (Crossref)*, https://doi.org/10.1177/003804070607900104.

35. Goodman, Cunningham, et al. *Final Report of the Women’s Experiences in College Engineering Project.* . Goodman Research Group, Inc., 2002.

36. Greene, Jennifer C., et al. “Toward a Conceptual Framework for Mixed-Method Evaluation Designs.” *Educational Evaluation and Policy Analysis*, vol. 11, no. 3, Sept. 1989, pp. 255–74. *DOI.org (Crossref)*, https://doi.org/10.3102/01623737011003255.

37. Grootaert, Christiaan, et al., editors. *Understanding and Measuring Social Capital: A Multidisciplinary Tool for Practitioners*. World Bank, 2002.

38. Hill, Catherine, et al. *Why so Few? Women in Science, Technology, Engineering, and Mathematics*. AAUW, 2010.

39. Holland, Dorothy C., and Margaret A. Eisenhart. *Educated in Romance: Women, Achievement, and College Culture*. University of Chicago Press, 1990.

40. Korte, R., and S. Lin. “Investing for Success: Newcomer Socialization and the Development of Social Capital.” *Proceedings of the Academy of Human Resource Development Conference*, 2011.

41. Leech, Nancy L., and Anthony J. Onwuegbuzie. “A Typology of Mixed Methods Research Designs.” *Quality & Quantity*, vol. 43, no. 2, Mar. 2009, pp. 265–75. *DOI.org (Crossref)*, https://doi.org/10.1007/s11135-007-9105-3.

42. Lin, Nan. “Inequality in Social Capital.” *Contemporary Sociology*, vol. 29, no. 6, Nov. 2000, p. 785. *DOI.org (Crossref)*, https://doi.org/10.2307/2654086.

43. ---. *Social Capital: A Theory of Social Structure and Action*. Repr, Cambridge Univ. Pr, 2007.

44. Margolis, Jane, et al. “The Anatomy of Interest: Women in Undergraduate Computer Science.” *Women’s Studies Quarterly*, vol. 28, no. 1/2, 2000, pp. 104–27.

45. Marra, Rose M., et al. “Leaving Engineering: A Multi-Year Single Institution Study.” *Journal of Engineering Education*, vol. 101, no. 1, Jan. 2012, pp. 6–27. *DOI.org (Crossref)*, https://doi.org/10.1002/j.2168-9830.2012.tb00039.x.

46. Martin, Julie P., et al. “Developing a Survey Instrument to Characterize Social Capital Resources Impacting Undergraduates’ Decision to Enter and Persist in Engineering.” *Frontiers in Education Conference (FIE)*, 2011.

47. Maskell, Peter. “Social Capital, Innovation, and Competitiveness.” *Social Capital: Critical Perspectives*, Oxford University Press, pp. 111–23.

48. Massey, Douglas S., and Mary J. Fischer. “Stereotype Threat and Academic Performance: New Findings from a Racially Diverse Sample of College Freshmen.” *Du Bois Review: Social Science Research on Race*, vol. 2, no. 1, Mar. 2005, pp. 45–67. *DOI.org (Crossref)*, https://doi.org/10.1017/S1742058X05050058.

49. Miles, Matthew B., and A. M. Huberman. *Qualitative Data Analysis: An Expanded Sourcebook*. 2nd ed, Sage Publications, 1994.

50. Mukhopadhyay, Carol C. “A Feminist Cognitive Anthropology: The Case of Women and Mathematics.” *Ethos*, vol. 32, no. 4, Dec. 2004, pp. 458–92. *DOI.org (Crossref)*, https://doi.org/10.1525/eth.2004.32.4.458.

51. National Science Foundation, Division of Science Resources Statistics. *S&E Degrees, by Race/Ethnicity of Recipients: 2008 –2018*. National Science Foundation, 2020.

52. National Science Foundation, National Center for Science and Engineering Statistics. *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2017*. Special Report NSF 17-310, National Science Foundation, 2017.

53. Pascarella, Ernest T., and Patrick T. Terenzini. *How College Affects Students*. First edition, Jossey-Bass Publishers, 1991.

54. Perna, Laura, et al. “The Contribution of HBCUS to the Preparation of African American Women for Stem Careers: A Case Study.” *Research in Higher Education*, vol. 50, no. 1, Feb. 2009, pp. 1–23. *DOI.org (Crossref)*, https://doi.org/10.1007/s11162-008-9110-y.

55. Portes, Alejandro. “Social Capital: Its Origins and Applications in Modern Sociology.” *Annual Review of Sociology*, vol. 24, no. 1, Aug. 1998, pp. 1–24. *DOI.org (Crossref)*, https://doi.org/10.1146/annurev.soc.24.1.1.

56. Puccia, Ellen, et al. “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*, vol. 8, no. 1, Dec. 2021, p. 20. *DOI.org (Crossref)*, https://doi.org/10.1186/s40594-021-00277-0.

57. Putnam, Robert. “The Strange Disappearance of Civic America.” *American Prospect*, vol. 7, no. 24, 1996, pp. 34–48.

58. Robinson, J. Gregg, and Judith S. McIlwee. “Men, Women, and the Culture of Engineering.” *The Sociological Quarterly*, vol. 32, no. 3, Sept. 1991, pp. 403–21. *DOI.org (Crossref)*, https://doi.org/10.1111/j.1533-8525.1991.tb00166.x.

59. Sax, Linda J. *The Gender Gap in College: Maximizing the Developmental Potential of Women and Men*. 1st ed, Jossey-Bass, 2008.

60. Seymour, Elaine. "The Role of Socialization in Shaping the Career-Related Choices of Undergraduate Women in Science, Mathematics, and Engineering Majors." *Annals of the New York Academy of Sciences*, vol. 869, no. 1 Women in Science, Apr. 1999, pp. 118–26. *DOI.org (Crossref)*, https://doi.org/10.1111/j.1749-6632.1999.tb08366.x.

61. ---. "Tracking the Processes of Change in US Undergraduate Education in Science, Mathematics, Engineering, and Technology." *Science Education*, vol. 86, no. 1, Jan. 2002, pp. 79–105. *DOI.org (Crossref)*, https://doi.org/10.1002/sce.1044.

62. Seymour, Elaine, and Nancy M. Hewitt. *Talking about Leaving: Why Undergraduates Leave the Sciences*. Westview Press, 1997.

63. Shapiro, Casey A., and Linda J. Sax. "Major Selection and Persistence for Women in STEM." *New Directions for Institutional Research*, vol. 2011, no. 152, Dec. 2011, pp. 5–18. *DOI.org (Crossref)*, https://doi.org/10.1002/ir.404.

64. Shore, Bradd. *Culture in Mind: Cognition, Culture, and the Problem of Meaning*. Oxford University Press, 1996.

65. Skvoretz, John, et al. "Pursuing an Engineering Major: Social Capital of Women and Underrepresented Minorities." *Studies in Higher Education*, vol. 45, no. 3, Mar. 2020, pp. 592–607. *DOI.org (Crossref)*, https://doi.org/10.1080/03075079.2019.1609923.

66. Smith, Chrystal A. S., et al. "Social Capital From Professional Engineering Organizations and the Persistence of Women and Underrepresented Minority Undergraduates." *Frontiers in Sociology*, vol. 6, May 2021, p. 671856. *DOI.org (Crossref)*, https://doi.org/10.3389/fsoc.2021.671856.

67. Snijders, Tom A. B. "Prologue to the Measurement of Social Capital." *The Tocqueville Review*, vol. 20, no. 1, Jan. 1999, pp. 27–44. *DOI.org (Crossref)*, https://doi.org/10.3138/ttr.20.1.27.

68. Stevens, Reed, et al. "Becoming an Engineer: Toward a Three Dimensional View of Engineering Learning." *Journal of Engineering Education*, vol. 97, no. 3, July 2008, pp. 355–68. *DOI.org (Crossref)*, https://doi.org/10.1002/j.2168-9830.2008.tb00984.x.

69. Strauss, Anselm L., and Juliet M. Corbin. *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory*. 2nd ed, Sage Publications, 1998.

70. Strauss, Claudia, and Naomi Quinn. *A Cognitive Theory of Cultural Meaning*. Cambridge University Press, 1997.

71. Summers, Michael F., and Freeman A. Hrabowski. “Preparing Minority Scientists and Engineers.” *Science*, vol. 311, no. 5769, Mar. 2006, pp. 1870–71. *DOI.org (Crossref)*, https://doi.org/10.1126/science.1125257.

72. Tonso, Karen L. “Teams That Work: Campus Culture, Engineer Identity, and Social Interactions.” *Journal of Engineering Education*, vol. 95, no. 1, Jan. 2006, pp. 25–37. *DOI.org (Crossref)*, https://doi.org/10.1002/j.2168-9830.2006.tb00875.x.

73. ---. “The Impact of Cultural Norms on Women*.” *Journal of Engineering Education*, vol. 85, no. 3, July 1996, pp. 217–25. *DOI.org (Crossref)*, https://doi.org/10.1002/j.2168-9830.1996.tb00236.x.

74. Trenor, Julie Martin, Shirley L Yu, et al. “Influences for Selecting Engineering: Insights on Access to Social Capital from Two Case Studies.” *Proceedings of the 38th Annual Frontiers in Education Conference*, 2008.

75. Trenor, Julie Martin, Shirley L. Yu, et al. “The Relations of Ethnicity to Female Engineering Students’ Educational Experiences and College and Career Plans in an Ethnically Diverse Learning Environment.” *Journal of Engineering Education*, vol. 97, no. 4, Oct. 2008, pp. 449–65. *DOI.org (Crossref)*, https://doi.org/10.1002/j.2168-9830.2008.tb00992.x.

76. Vogt, Christina M., et al. “A Social Cognitive Construct Validation: Determining Women’s and Men’s Success in Engineering Programs.” *The Journal of Higher Education*, vol. 78, no. 3, 2007, pp. 337–64. *DOI.org (Crossref)*, https://doi.org/10.1353/jhe.2007.0019.

77. Wao, Hesborn, et al. “Social Networks and Women and Underrepresented Undergraduates’ Engineering Major Declaration.” *International Journal of STEM Education*, vol. 10, no. 25, 2023.

78. Seymour, Elaine, and Anne-Barrie Hunter. *Talking about Leaving Revisited: Persistence, Relocation, and Loss Undergraduate STEM Education*. Spring Nature Switzerland AG, 2019.