Paper ID #21856

Investigating Student Perceptions of an Engineering Department's Climate: The Role of Peer Relations

Dr. Susannah C. Davis, Oregon State University

Susannah C. Davis is a postdoctoral research associate in the School of Chemical, Biological and Environmental Engineering at Oregon State University. She received her Ph.D. and M.Ed. from the University of Washington, and her B.A. from Smith College. She is currently working on the NSF-funded REvolutionizing engineering and computer science Departments (RED) project at OSU. Her research focuses on organizational learning and change, particularly in higher education; learning in the workplace; curricular and pedagogical development; and the preparation of professionals for social justice goals.

Naeun Cheon, University of Washington
Ms. Elba Camila Moise, University of Washington
Dr. Susan Bobbitt Nolen, University of Washington

Professor of Learning Sciences & Human Development

Investigating Student Perceptions of an Engineering Department's Climate: The Role of Peer Relations

Diversity in engineering remains low despite decades of rhetoric and efforts to broaden participation and retention. Social and cultural groups historically underrepresented in STEM education and careers, particularly women and people of color, enter engineering at lower rates and leave at substantially higher rates [1]-[3]. Several studies found that perceptions of an unwelcoming institutional climate can be detrimental to students' sense of belonging and persistence [3], [4]-[7]. Researchers have referred to this as the "chilly climate" [8]-[9] or "climate of intimidation" [10] members of these groups encounter in engineering. In the broader undergraduate population, individual perceptions of the campus climate, including interactions with peers, have been related to persistence [11]-[14]. More research is needed to understand the factors that contribute to students' perceptions of unwelcoming campus and/or disciplinary climates, particularly as those factors relate to underrepresented students' persistence in engineering.

Researchers across disciplines in higher education have linked student engagement, student success, and student persistence to their sense of belonging [11], [15]-[21]. Many researchers' conceptions of 'sense of belonging' are founded on Tinto's [20] model of students' persistence/withdrawal behavior. Tinto [20] found that students' sense of belonging is based on their formal and informal academic integration (through academic achievement and faculty interaction) and social integration (through extracurricular activities and peer interaction). Tinto argued that when students have a greater sense of belonging, or affiliation and identification with the university community, they are more likely to remain in college. In a more recent quantitative survey study, Hoffman and colleagues [22] found five factors underlying first-year college students' sense of belonging: perceived peer support, perceived faculty support/comfort, perceived classroom comfort, perceived isolation, and empathetic faculty understanding. Of these factors, perceived peer support had the highest explanatory value, explaining 38.8% of the total variance. Other studies have highlighted the role of positive faculty interactions, particularly outside the classroom, as positive influences on students' sense of belonging [16], [23].

In engineering, students' sense of belonging is closely related to their self-identification as engineers. Tonso [24], who defined engineering identity as a sense of belonging, found that gender and other social variables affect students' power and status, which in turn affects their identification with engineering. Meyers and colleagues [25] found that students' self-identification as engineers was linked to a sense of belonging to the engineering college, as well as organizational recognition. In a survey study conducted in the Netherlands, Meeuwisse and

colleagues [26] found that quality faculty and peer interactions positively impacted students' sense of belonging.

Previous research highlights the importance of both a sense of belonging and self-identification as engineers for persistence in the major [22], [24]-[25], [27]-[31]. For example, Marra and colleagues' [29] investigation of the reasons students left engineering found that the only significant non-academic factor for students' decision to leave engineering was lack of belonging. Their 'belonging' construct measured students' perception of belonging as well as their identification with the engineering curriculum and engineering career opportunities.

Research on underrepresented students' persistence in STEM overwhelmingly indicates that social and interpersonal factors, more than other factors such as academic preparation and performance, impact underrepresented STEM students' persistence [3], [6], [32]-[35]. For example, persistence is hindered by underrepresented students' experiences with microaggressions, bias, or discrimination [3], [36]-[38] and feelings of isolation and lack of belonging [3], [6], [29]-[31], [39]-[40].

Relationships and interactions with faculty and peers are particularly salient social and interpersonal factors connected to engineering identity and persistence in STEM fields. Several studies argue that relationships with faculty impact students' success, identification, and persistence [41]-[43]. Considerable research suggests that peer relations also play an important role in engineering identification and persistence (e.g., [6], [31], [36], [44]-[46]). For example, Chang and colleagues' [36] study of 3,670 students across 217 institutions intending to major in STEM found that strong peer support improved underrepresented students' persistence. Palmer and colleagues' [10] qualitative study of students of color in STEM described how peer group support, including group study, had both academic and social benefits that impacted persistence. Research has also found that peer interaction within formal campus cultural organizations provides a sense of cultural connection and community for underrepresented students and promotes social integration [47]-[52]. Ong and colleagues' [6] qualitative study of 39 women of color across STEM disciplines found that in addition to participation in formal campus groups, peer relationships themselves had a positive impact on persistence when they acted as a type of counterspace—a safe space that allowed underrepresented students temporary relief from negative experiences in STEM higher education such as isolation, microaggressions, and discrimination while simultaneously creating physical or conceptual space for students to promote their own learning and establish and maintain a positive collegiate climate for themselves [6], [53]-[54]. Of the five types of counterspaces these researchers identified (including peer-to-peer relationships, mentoring relationships, national STEM diversity conferences, STEM and non-STEM campus student groups, and STEM departments), peer-to-

peer relationships was the counterspace most frequently cited as helpful to students' persistence (74.4% of participants).

Context for the present study

This paper focuses on our analysis of responses to open-ended items on an anonymous climate survey given to students in a single, large engineering department at a public university. Students responded to both forced-choice and open-ended items. Results of our quantitative analysis of forced-choice responses are reported in depth elsewhere [55] and summarized here to give context for the qualitative analysis of open-ended items. Survey data indicated that students generally view their unit as a welcoming, inclusive environment in which they feel they belong. Overall, students gave an average rating of 4.2 on a Likert-type scale of 1 (strongly disagree the climate is welcoming) to 5 (strongly agree) to describe how welcoming the departmental climate was. However, students rated the climate in the program as more welcoming for male and US-born students (referred to as dominant-group students) than for students from other identity groups (labeled non-dominant group students). While students across all identity groups saw the climate as more welcoming for students with dominant versus non-dominant identities, both women and students of color viewed this gap as wider compared to their male or White peers.

Engineering identity (which, consistent with findings from previous research, involved items related to sense of belonging and identification with the discipline; see Appendix for all scale items) and persistence differed by race and gender; both engineering identity and persistence were lower for students of color and women [55]. Gender, how welcoming the climate was for non-dominant groups, and faculty support all significantly and independently predicted students' engineering identity. The relationships between gender and both engineering identity and persistence were completely mediated by peer relations, but were not significantly mediated by faculty support. Unlike gender, race had a significant independent effect on both engineering identity and persistence that was not mediated by other predictors. This suggests that other factors not captured by this set of predictors influenced their identification with the discipline and their persistence.

To better understand aspects of the program climate that influenced persistence and disciplinary identification, we conducted a qualitative analysis of responses to two open-ended items which asked students to state identify the "best" part of the program and what they would change if they could "change one thing" about the program. Our research questions were:

1. What aspects of the program climate were salient as attractors and detractors to students with different social identities?

2. How does the role of peer relations manifest in the open-ended responses from students with different social identities?

Methods

This analysis draws from data from an undergraduate climate survey (n=277) implemented at a multidisciplinary engineering department within a large public university on the West Coast. Undergraduate students from the engineering department were invited to participate anonymously in an online survey during spring quarter in 2017 that investigated students' perceptions of the engineering department's climate; perceived faculty, advisor, and TA support; peer relations; experiences with microaggressions; identification with the discipline; and how likely they were to stay or leave engineering. Students were asked to indicate which of multiple social identities they identified with and allowed to choose more than one. Of the 277 participants, 56% identified as White Non-Latinx, 25% as at least one racial category other than White Non-Latinx, 51% identified as male, and 27% as female, with equal numbers of respondents in their final year and in their middle years.

The survey was collected using Qualtrics, an online survey program. We used Qualtrics and SPSS for quantitative data analysis, and ATLAS.ti for qualitative analysis of two open-ended items. Scales included Engineering Identity, Engineering Persistence, Peer Relations, and Faculty Support (see Appendix). Perceptions of welcoming (vs. hostile) climate for each of 14 different identity groups were individually assessed, resulting in scales for dominant (US-born, Male) and non-dominant (all other identities) reference groups (see Appendix). Additionally, students answered two open-ended questions: (1) If you could change one thing about [program name], what would it be?; and (2) What is the best thing about being a [program name] student? Data analysis of responses to the two open-ended survey items began with an initial reading and open coding of all responses [56]-[57]. Members of the research team met regularly to compare open coding observations and to develop a code list based on our emergent observations as well as constructs derived from the literature on student belonging, identity, and climate and diversity in engineering. We engaged multiple coding passes, during which we refined the code list based on emergent themes and constructs. When we implemented focused coding of all data, we resolved any discrepancies between coding choices through deliberation and consensus. Open-ended responses were first hand-coded during open coding, and subsequent coding work was conducted on ATLAS.ti, a qualitative data analysis program. We compared responses within and across social identity groups in relation to our research questions, creating memos to support our emerging analysis [57].

Findings

Students' responses to the two open-ended items ([1] If you could change one thing about [program name], what would it be?; and [2] What is the best thing about being a [program name] student?) supported the quantitative finding that women viewed the climate as less welcoming for students from non-dominant identity groups (including themselves) than students from dominant identity groups. In response to the first open-ended question, substantially more women (19.3%) than men (4.9%) responded that the one thing about the program they would change was related to the institutional and interpersonal climate of the department. This category included issues of diversity and inclusion, such as the ways in which individuals, groups, and sub-disciplines are or are not included in the program.

Some of these women's responses to Question 1 spoke explicitly about gender; for example, "More female full professors and staff and inclusive language" and "I would hope to have more women in engineering in general but mainly in my field, as well as be able to find ways to connect with those in this field in a more interactive way." Others highlighted the experiences of international students; for example, "It is very exclusive, I don't feel like international and non-American students are very welcome to the [program name] community of professors and domestic students" and "More recognition to students who are not native English speakers and how hard they have to work." Several responses indicated the desire for more diversity and inclusion in more general terms, such as: "More diversity and accepting environment" and "Inclusivity, and not just the buzzword but actual actions that support it." One response spoke about wanting more inclusivity within the student body: "That it wasn't so clique-oriented...people stick to the friend groups they have made since their first year here." A white female transfer student said, "I definitely think that I get underestimated a lot."

In contrast, there were only five responses from male students to the first open-ended question that related to climate, diversity, and inclusion. It's notable that two of these five responses were from students of color and a third was from an international student who didn't indicate his race. One male student of color wrote, "Make the set of majors more accepting to those of different backgrounds." One of the two responses to this category from White men discussed the need for more inclusion of all the sub-disciplines represented in the unit, while the other response from a White male railed against "this political correctness shenanigans" and "this silly one sided and self-righteous liberal ideology pushed by faculty." All of the responses to the question about the one thing they would change that spoke of the need for more diversity and inclusion of underrepresented groups came from women and/or students of color and/or international students.

Community was the most prominent theme within responses to the second open-ended question about the best thing about being a student in the program; 44.4% of all responses to this question were related to a positive community in the program. Responses in this category had to do with either the general program community, peers in the program, and/or program faculty. 17 responses used the word "community" in their response; for example, "They are a very accepting community," "The tight-knit and supportive community that makes the workload manageable," and "The community is welcoming and there are so many students to connect with to work on homework and other school related stuff." A greater proportion of women (57.6%) than men (39.6%) indicated that the community, including faculty and peers, was the best thing about being a student in the program.

The community theme included responses that spoke about the importance of a positive general program community, peers, and/or faculty. Of these, peer relationships were most frequently cited as the best thing about being a student in the program (23.4% of all responses to Question 2). As with the overarching community theme, women (30.5%) were substantially more likely than men (20.8%) to indicate that peer relationships were the best thing about their membership in the program. This emphasis from female students in particular on community and positive peer relations as the best thing about the program is consistent with our finding from the quantitative analysis that peer relations mediated the effects of gender, how welcoming the climate was perceived to be for non-dominant students, and faculty support on engineering identity and the effects of gender and the climate for non-dominant groups on persistence [55].

Across genders, most peer-related responses could be categorized into themes about suffering/working together through the difficult curriculum and workload, friends, and having a positive/supportive community of peers. The suffering together theme included responses such as: "I like having a supportive community that suffers through homework with me" and "I made a few friends who are always willing to help and understand the frustration." Along similar lines, students spoke positively about working in groups, helping each other, and learning together. These responses included: "Turning your study group into your friend group" and "Feel-good study groups". Similarly, one woman of color responded: "Everyone is willing to help each other out, whether it's homework or studying. You could generally walk up to anybody from your class and they would be very willing to help you. Additionally, almost everybody knows each other by their first and last name."

The importance of friends within the program was another theme in these responses. 16 peer-related responses explicitly used the word "friends" in answer to Question 2, such as: "We all work together to solve tough homework problems and a lot of us are friends outside of class"; "Even if two peers aren't friends, you will still see them come together to find a solution because the concepts we learn are very difficult. Everyone knows that we have to work together and

therefore are respectful"; and "The community feels like a big group of friends." Several responses also spoke about the "sense of camaraderie" in the department.

While far more women and students of color indicated that positive, supportive peer relationships were the best thing about the program than those who talked about the peer community negatively, there were a few responses to the first open-ended question that indicated that not everyone felt included in their peer community. Two men of color spoke about their desire to connect to peers in the program more. One man who identified with an underrepresented minority group said, "I would prefer to have friends within [program name] who I could hang out with outside of class and work on homework with." Another man of color indicated that the program should "encourage more friendships." Like the female international student who spoke about the "exclusive… community of professors and domestic students" mentioned above, another international student who didn't specify their gender remarked: "Make sure all of the students in the group are not ignoring the international student in their group." While these responses were in the minority, given the relatively low numbers of international students and students of color who responded to the survey, they may be indicative of a larger issue. If some students of color and/or international students are experiencing negative peer relations and/or isolation and lack of belonging as has been found in previous research of students of color in STEM [3], [6], [29]-[31], [39]-[40], that may explain why our quantitative analysis did not find peer relations mediating the engineering identity and persistence of students of color.

Discussion

Both our quantitative findings [55] and our qualitative findings reported here highlight that women, a traditionally underrepresented group in engineering, view the departmental climate differently—and more negatively—than their male counterparts. Nearly 20% of women responded that the one thing about the program they would change was related to the departmental climate, and typical responses explicitly or implicitly spoke about their desire for more diversity and inclusivity within the program. This is consistent with previous research that highlights how underrepresented STEM students' negative perceptions of campus and/or departmental climates as well as their negative experiences in these spaces (e.g., discrimination and bias) hinder their sense of belonging and persistence [3], [6], [10], [36]-[38], [58]. Our quantitative analysis also found that women and students of color in the program thought the program was less welcoming to non-dominant groups, identified less with engineering, and were more likely to express doubts about persisting [55]. The open-ended responses that call for more diversity and inclusivity in the program at large and in relations among faculty and peers suggest that while overall students indicated that the program was relatively welcoming, there is

important work needed to improve the climate for and experiences of students from underrepresented groups.

Although the departmental climate was rated less welcoming for non-dominant than dominant groups, its effects on women's engineering identification and persistence was mediated by academic and social relationships with peers [55]. Qualitative findings from this survey also underscore the importance of a positive social and interpersonal community in developing a sense of belonging and persistence in engineering. Nearly half (44.4%) of all students responded that the best thing about being a student in the program was being a part of a supportive community; this included responses identifying a generally positive community as well as responses more specifically identifying positive relationships with faculty and peers. This is in line with a significant body of research that suggests that social and interpersonal factors have a greater effect than other factors such as academic preparation or the difficulty of the curriculum on underrepresented STEM students' sense of belonging and persistence [3], [6], [32]-[35]. Of these social and interpersonal factors, faculty and peer support are most frequently cited as having a positive impact on underrepresented sense of belonging and persistence [16], [20]-[27], [29]-[31]. Survey responses suggested that many students felt that the community, including faculty and peers, was welcoming and supportive, which helped them deal with the difficulty of the curriculum and the program workload. In contrast, several negative responses from women, people of color, and/or international students about the social climate demonstrated that there is still work to be done to make the community in the program more inclusive to traditionally underrepresented students. This is in line with the finding in the quantitative analysis that women rated their peer relations somewhat lower than men; those that rated their peer groups more supportive were more likely to report identification with engineering and plans to persist.

Peer relationships was the largest sub-category within the community theme. Peer support was described by students as suffering or working together through a tough workload, sometimes through group study; having friends within the program; and having a positive and supportive community of peers. These themes are present in other literature on the importance of peer group interaction, support, and mentoring for underrepresented students' persistence in STEM [3], [6], [31], [36], [44]-[46] and in higher education more generally [20]-[21], [59]-[60]. Participants in our context discussed the academic and social benefits of peer relationship and group study, just as participants did in Palmer and colleagues' [10] and Ong and colleagues' [6] studies. Peers sharing hardship, sometimes described as "suffering together" in responses to this climate survey, was highlighted as an aspect of the culture of engineering education in Godfrey and Parker's [61] ethnographic study. They found that "the shared hardship was likened to a boot camp mentality seen as binding students into a shared identity" (p. 12). This "shared identity" may help students feel a sense of belonging. There may be ways to promote these academic and social benefits of peer relations within the classroom or curriculum. For example, Meeuwisse

and colleagues' [26] found that more cooperative learning environments had a positive impact on students' formal and informal interactions with peers and faculty, which in turn had a positive impact on students' sense of belonging.

Ong and colleagues [6] described a critical function of peer relationships: they can provide a counterspace for underrepresented students—a physical or conceptual space that offers temporary relief from negative experiences such as microaggressions, bias, and/or discrimination. As a counterspace, peer relationships (whether within or outside formal program-related spaces) may help students maintain a positive climate for themselves even within a larger context that may be less welcoming to underrepresented students than their White male peers. The five types of counterspaces that Ong and colleagues [6] described were "locations of activity or thought that counter the dominant culture in STEM, offering the potential to disrupt historical power structures of STEM culture" (p. 27). Participants in Ong and colleagues' study found informal support from other underrepresented peers, sometimes strategically choosing the same courses and studying and/or socializing together, which helped address feelings of not belonging and experiences with microaggressions in their STEM environments. In formal and informal spaces, peers shared knowledge, supported each other, collaborated rather than competed, and validated each other's experiences. That 30.5% of female responses indicated that peer relationships were the best thing about being a student in their engineering program, and their responses described similar functions to as those described by Ong and colleagues (e.g., supporting each other, sharing knowledge, studying together), indicates that peers may be acting as a counterspace buffering negative aspects of the climate for some underrepresented students in the program.

Conclusion

Taken together, our survey results suggest that the social climate and community in the department, and particularly peer relations, plays an important role in students' (especially underrepresented students') sense of belonging and persistence in engineering. Quantitative analysis showed that peer relations mediated the effects of faculty support and gender on engineering identification and persistence, and women's greater proportion of responses to open-ended items focusing on the role of community and peers also suggests that efforts to improve peer relations may be a key part of efforts to increase retention and identification among underrepresented students. Both curricular and extracurricular activities could encourage student relationships and connections. Given that engineering work necessitates teamwork and research has found that teamwork improves learning [62]-[64], inclusive teaming practices in the context of courses may be a promising place to start. In order for peer relations within teamwork to act as a potential counterspace [6] and disrupt existing power relations and negative interpersonal experiences of underrepresented students, attention must be paid to the ways in which students'

social identities impact students' status and interactions within teams [24], and students should be exposed to appropriate, scaffolded opportunities to learn inclusive teaming skills. Within our program, these survey results have prompted the development of an inclusive teaming professional learning community (PLC) among faculty to explore inclusive teaming skills and experiences and to design curricular activities to support supportive interpersonal interactions across difference. However, efforts such as these should be implemented in the context of larger social and cultural reform to make the climate at classroom, departmental, and institutional levels more welcoming for all [65]-[66].

Acknowledgments
This material is based upon work supported by the National Science Foundation under Grant EEC 1519467. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

References

1. Committee on Equal Opportunities in Science and Engineering, "Broadening participation in America's STEM workforce: 2011–2012 biennial report to Congress," National Science Foundation, Arlington, VA, 2014. Retrieved from https://www.nsf.gov/od/oia/activities/ceose/reports/Full_2011-2012_CEOSE_Report_to_Congress_Final_03-04-2014.pdf
2. S. Hurtado, K. Eagan, and M. Chang, "Degrees of success: Bachelor's degree completion rates among initial STEM majors," *Higher Education Research Institute at UCLA*, 2010.
3. M. Ong, C. Wright, L. Espinosa, and G. Orfield, "Inside the double bind: A synthesis of empirical research on undergraduate and graduate women of color in science, technology, engineering, and mathematics," *Harvard Educational Review,* vol. 81 no. 2, pp. 172–208, 2011.
4. M. A. Beasley, and M. J. Fischer, "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 no. 4, pp. 427–448, 2012.
5. J. C. Blickenstaff, "Women and science careers: Leaky pipeline or gender filter?" *Gender and Education*, vol. 17 no. 4, pp. 369–386, 2005.
6. M. Ong, J. M. Smith, and L. T. Ko, "Counterspaces for women of color in STEM higher education: Marginal and central spaces for persistence and success," *Journal of Research in Science Teaching*, vol. 9999 no. 0, pp. 1–40, 2017.
7. B. Sandler, L. Silverberg, and R. Hall, "The chilly classroom climate: A Guide to improve the education of women," Washington DC: National Association of Women in Education, 1996. Available: http://www.eric.ed.gov/PDFS/ED396984.pdf.
8. R. M. Hall and B. R. Sandler, *The Classroom Climate: A Chilly Climate for Women?* Washington, D.C.: Association of American Colleges, 1982.
9. G. M. Walton, J. M. Peach, C. Logel, S. J. Spencer, and M. P. Zanna, "Two brief interventions to mitigate a "chilly climate" transform women's experience, relationships, and achievement in engineering," *Journal of Educational Psychology,* vol. 107 no. 2, pp. 468-485, 2015.
10. R. T. Palmer, D. C. Maramba, and T. E. Dancy, "A qualitative investigation of factors promoting the retention and persistence of students of color in STEM*" The Journal of Negro Education,* vol. 80 no. 4, pp. 491–504, 2011.
11. L. R. M. Hausmann, J. W. Schofield, and R. L. Woods, "Sense of belonging as a predictor of intentions to persist among African American and White first-year college students," *Research in Higher Education,* vol. 48 no. 7, pp. 803-839, 2007.

12. S. Hurtado, J. F. Milem, A. R. Clayton-Pedersen, and W. R. Allen, "Enhancing campus climates for racial/ethnic diversity: Educational policy and practice," *Review of Higher Education,* vol. 21 no. 3, pp. 279-302, 1998.
13. S. Hurtado, J. F. Milem, A. R. Clayton-Pedersen, and W. R. Allen, "Enacting diverse learning environments: Improving the climate for racial/ethnic diversity in higher education," *ASHE-ERIC Higher Education Report,* vol. 26 no. 8, Washington, DC: George Washington University, 1999
14. S. R. Rankin and R. D. Reason, "Differing perceptions: How students of color and White students perceive campus climate for underrepresented groups," *Journal of College Student Development,* vol. 46, pp. 43-61, 2005.
15. J. B. Berger and J. F. Milem, "The role of student involvement and perceptions of integration in a causal model of student persistence, *Research in Higher Education,* vol. 40 no. 6, pp. 641–664, 1999.
16. S. H. Hurtado and L. Ponjuan, "Latino educational outcomes and the campus climate," *Journal of Hispanic Higher Education,* vol. 4 no. 3, pp. 235–251, 2005.
17. J. F. Milem and J. B. Berger, "A modified model of college student persistence: Exploring the relationship between Astin's theory of involvement and Tinto's theory of student departure," *Journal of College Student Development,* vol. 38 no. 4, pp. 387-400, 1997.
18. J. H. Schuh, V. L. Triponey, L. L. Heim and K. Nishimura, "Student involvement in historically black Greek letter organization," *NASPA Journal,* vol. 29, no. 4, pp. 274-281, 1992.
19. T. L. Strayhorn, F. Bie, L. Long III, and B. A. Barrett, "African American and Hispanic STEM Students' Engagement at Predominantly White Institutions," in *Proceedings of the American Society for Engineering Education Annual Conference and Exposition, Indianapolis, IN, 2014*.
20. V. Tinto, *Leaving college: Rethinking the causes and cures of student attrition* (2nd ed.). Chicago, IL: University of Chicago Press, 1993.
21. V. Tinto, "Research and practice of student retention: what next?," *Journal of College Student Retention: Research, Theory and Practice,* vol. 8 no. 1,pp. 1–19, 2006.
22. M. Hoffman, J. Richmond, J. Morrow, and K. Salomone, "Investigating 'sense of belonging' in first-year college students," *Journal of College Student Retention*, vol. 4 no. 3, pp. 227–256, 2003.
23. T. M. Freeman, L. H. Anderman, and J. M. Jensen, "Sense of belonging in college fresh-men at the classroom and campus levels," *Journal of Experimental Education,* vol. 75 no. 3, pp. 203–220, 2007.
24. K. Tonso, *On the outskirts of engineering*. Rotterdam, The Netherlands: Sense Publishers, 2007.

25. K. L. Meyers, M. W. Ohland, A. L. Pawley, S. E. Silliman, and K. A. Smith, "Factors relating to engineering identity," *Global Journal of Engineering Education*, vol. 14 no. 1, pp. 119–131, 2012.
26. M. Meeuwisse, S. Severiens, and E. Born, "Learning Environment, Interaction, Sense of Belonging and Study Success in Ethnically Diverse Student Groups," *Research in Higher Education,* vol. 51 no. 6, pp. 528-545, 2010.
27. M. Eliot and J. Turns, "Constructing professional portfolios: Sense-making and professional identity development for engineering undergraduates," *Journal of Engineering Education,* vol. 100 no. 4, pp. 630-654, 2011.
28. J. Margolis and A. Fisher, *Unlocking the Clubhouse: Women in Computing*. MIT Press: Cambridge, MA, 2002.
29. R. M. Marra, K. A. Rodgers, D. Shen, and B. Bogue, "Leaving Engineering : A Multi-Year Single Institution Study," *Journal of Engineering Education*, vol. 101 no. 1, pp. 6–27, 2012.
30. E. Seymour and N. Hewitt, *Talking About Leaving: Why Undergraduates Leave the Sciences*. Boulder, Co.: Westview Press, 1997.
31. E. D. Tate and M. Linn, "How does identity shape the experiences of women of color engineering students?," *Journal of Science Education and Technology,* vol. 14 no. 5–6, pp. 483–493, 2005.
32. H. B. Carlone and A. Johnson, "Understanding the science experiences of successful women of color: Science identity as an analytic lens," *Journal of Research in Science Teaching,* vol. 44 no. 8, pp. 1011–1245, 2007.
33. S. M. Ovink and B. D. Veazey, "More than 'Getting Us through': A Case Study in Cultural Capital Enrichment of Underrepresented Minority Undergraduates," *Research in Higher Education,* vol. 52 no. 4, pp. 370-394, 2011.
34. R. Varma, "Women in information technology: A case study of undergraduate students in a minority-serving institution," *Bulletin of Science, Technology, and Society,* vol. 22 no. 4, pp. 274–282, 2002.
35. R. Varma, A. Prasad, and D. Kapur, "Confronting the 'socialization' barrier: Crossethnic differences in undergraduate women's preference for IT education," in *Women and information technology: Research on underrepresentation*, J. M. Cohoon, & W. Aspray, Eds. Cambridge, MA: MIT Press, 2006, pp. 301–322.
36. M. J. Chang, J. Sharkness, S. Hurtado, and C. B. Newman, "What matters in college for retaining aspiring scientists and engineers from underrepresented racial groups," *Journal of Research in Science Teaching,* vol. 51 no. 5, p. 555–580, 2014.
37. S. Hurtado, N. L. Cabrera, M. H. Lin, L. Arellano, and L. L. Espinosa, "Diversifying science: Underrepresented student experiences in structured research programs," *Research in Higher Education,* vol. 50 no. 2, pp. 189–214, 2009.

38. T. J. Yosso, W. A. Smith, M. Ceja, and D. G. Solorzano, "Critical race theory, racial microaggressions, and campus racial climate for Latina/o undergraduates," *Harvard Educational Review,* vol. 79 no. 4, pp. 659–91, 2009.
39. C. Foor, S. Walden, and D. Trytten, "I wish that I belonged more in this whole engineering group: achieving individual diversity," *Journal of Engineering Education,* vol. 96, no. 2, pp. 103-115, 2007.
40. J. D. Lee, "Which kids can become scientists? Effects of gender, self-concepts, and perceptions of scientists," *Social Psychology Quarterly,* vol. 61, no. 3, pp. 199-219, 1998.
41. J. A. Gasiewski, M. K. Eagan, G. A. Garcia, S. Hurtado, and M. J. Chang, "From gatekeeping to engagement: A multicontextual, mixed method study of student academic engagement in introductory STEM courses," *Research in Higher Education,* vol. 53 no. 2, pp. 229–261, 2012.
42. G. D. Kuh, J. Kinzie, J. A. Buckley, B. K. Bridges, and J. C. Hayek, "What matters to student success: A review of the literature." Commissioned Report for the National Symposium on Post-secondary Student Success. Washington, DC: National Postsecondary Education Cooperative, 2006. Available: http://nces.ed.gov/npec/pdf/Kuh_Team_ExecSumm.pdf.
43. C. M. Vogt, "Faculty as a critical juncture in student retention and performance in engineering programs, *Journal Engineering Education,* vol. 97 no. 1, pp. 27–36.
44. L. L. Espinosa, "Pipelines and pathways: Women of color in undergraduate STEM majors and the college experiences that contribute to persistence," *Harvard Educational Review,* vol. 81 no. 2, pp. 209–241, 2011.
45. J. Grandy, "Persistence in science of high-ability minority students: Results of a longitudinal study," *Journal of Higher Education,* vol. 69 no. 6, pp. 589-620, 1998.
46. P. Q. Hall, *Problems and solutions in the education, employment and personal choices of minority women in science.* Washington, DC: American Association for the Advancement of Science, 1981.
47. Datnow, A., & Cooper, R. (1997). Peer networks of African American students in independent schools: Affirming academic success and racial identity. *The Journal of Negro Education, 66*, 56–72.
48. D. A. Guiffrida, "African American student organizations as agents of social integration," *Journal of College Student Development,* vol. 44 no. 3, pp. 304–319, 2003.
49. S. Hurtado, D. F. Carter, "Effects of college transition and perceptions of the campus racial climate on Latino college students' sense of belonging," *Sociology of Education,* vol. 70, pp. 324-345, 1997.
50. E. Litzler, "How underrepresented minority engineering students derive a sense of belonging from engineering," in *Proceedings of the American Society for Engineering Education Annual Conference & Exposition, Atlanta,GA, 2013*.

51. S. M. McClure, “Improvising masculinity: African American fraternity membership in the construction of a Black masculinity,” *Journal of African American Studies*, vol. 10 no. 1, pp. 57–73, 2006.
52. S. D. Museus, “The role of ethnic student organizations in fostering African American and Asian American students’ cultural adjustment and membership at predominantly White institutions,” *Journal of College Student Development,* vol. 49 no. 6, pp. 568–586, 2008.
53. D. Solórzano, M. Ceja, and T. Yosso, “Critical race theory, racial microaggressions, and campus racial climate: The experiences of African American college students,” *The Journal of Negro Education,* vol. 69 no. 1, pp. 60–73, 2000.
54. D. Solórzano and O. Villalpando, “Critical race theory, marginality, and the experience of minority students in higher education,” In *Emerging issues in the sociology of education: Comparative perspectives*, C.Torres and T. Mitchell, Eds. Albany: State University of New York Press, 1998, pp. 211–224.
55. S. C. Davis, E. C. Moise, N. Cheon, and S. B. Nolen, “Investigating Factors Related to Disciplinary Identification and Persistence in Undergraduate Engineering Education,” in *Proceedings from the American Educational Research Association Annual Meeting, New York City, NY*, *2018*.
56. S. B. Merriam, *Qualitative Research: A guide to design and interpretation*. San Francisco: Jossey-Bass, 2009.
57. M. B. Miles and A. M. Huberman, *Qualitative data analysis: An expanded sourcebook*. Thousand Oaks, CA: Sage, 1994.
58. G. A. Garcia and S. Hurtado, “Predicting Latina/o STEM persistence at HSIs and non-HSIs,” in *Proceedings from the American Educational Research Association Annual Meeting, New Orleans, LA, 2011*.
59. J. Bean, “Interaction Effects Based on Class Level in an Explanatory Model of College Student Dropout Syndrome,” *American Educational Research Journal,* vol. 22 no. 1, pp. 35-64, 1985.
60. J. P. Bean, “Nine themes of college student retention,” in *College student retention: Formula for student success*, A. Seidman, Ed. Washington, DC: ACE and Praeger, 2005, pp. 215–244.
61. E. Godfrey and L. Parker, “Mapping the Cultural Landscape in Engineering Education,” *Journal of Engineering Education,* vol. 99 no. 1, pp. 5-22, 2010.
62. S. G. Adams, “The Effectiveness of the E-Team Approach to Invention and Innovation,” *Journal of Engineering Education,* vol. 90, no. 4, pp. 597-600, 2001.
63. I. Horvath, J. Duhovnik, and P. Xirouchakis, “Learning the Methods and Skills of Global Product Realization in an Academic Virtual Enterprise,” *European Journal of Engineering Education*,, vol. 28, no. 1, pp. 83-102, 2003.
64. S. G. Rogelberg and S. M. Rumery, “Team Decision Quality, Time on Task, and Interpersonal Cohesion,” *Small Group Research*, vol. 27, no. 1, pp. 79-90, 1996.

65. M. F. Fox, G. Sonnert, and I. Nikiforova, “Successful programs for undergraduate women in science and engineering: Adapting versus adopting the institutional environment,” *Research in Higher Education,* vol. 50 no. 4, pp. 333–353, 2009.
66. L. Malcom and S. Malcom, “The double bind: The next generation,” *Harvard Educational Review*, vol. 81 no. 2, pp. 162–172, 2011.

Appendix

Engineering Persistence (scaled so higher values = greater commitment)

How likely are you to leave engineering in the next 6 months?

I don't know if this field is right for me.

I am not sure I will stay in this field.

Engineering Identity (5-point Likert scale)

I am feeling more and more like I belong in this field.

I am interested in the kind of work done in this field.

I identify with people in this field.

I am familiar with the kind of work done in this field.

I strongly identify with engineering as a career.

When I talk about engineers, I usually say "we" instead of "they."

Welcoming to Non-Dominant Students

Students separately rated how welcoming the School was for students of various groups on a 5-point anchored scale from Hostile (1) to Welcoming (5). Non-dominant groups were

People who identify as lesbian, gay, bisexual, asexual, queer

People who identify strongly with a religion

People with disabilities

People who identify as women

People who identify as transgender, genderqueer, gender nonconforming

People of color

Non-native English speakers

People born in other countries

Veterans/Active Military

Transfer students

INTO students (students who experienced a transition program for non-native speakers

People with family responsibilities

Positive Peer Relations (5-point Likert scale)

Please indicate how much you agree with each statement about interacting with peers.

My (program[1]) peers respect my ideas

In (program), people tend to ignore me (reversed)

Most of my (program) peers are comfortable working with me

It is too hard to work with people who do not share my home language (reversed)

I have friends in (program) with whom I can really be myself

Some of my peers think people like me should not be in (program) (reversed)

Working in groups, I am able to influence our decisions

I am not appreciated for the work I do in (program) groups (reversed)

My (program) peers often interact with me based on stereotypes (reversed)

I often socialize with (program) peers outside of class

Faculty Support (5-point Likert scale)

(Program) faculty…

Support my professional development as an engineer

Care about my learning

Care about my overall wellbeing

Accept me for who I am

Understand how stressful it is to be a (program) student

[1] On the survey, "program" was the name of the specific undergraduate program in engineering.