BRIDGING THE GAP:

INCREASING RETENTION RATES FOR FEMALE ENGINEERS IN THE UC SYSTEM

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March 22, 2017
Applied Policy Project 2016 - 2017
Prepared for the University of California, Office of the President

This report was prepared in partial fulfillment of the requirement for the Master in Public Policy degree in the Department of Public Policy at the University of California, Los Angeles. It was prepared at the direction of the Department and the University of California Office of the President as a policy client. The views expressed herein are those of the authors and not necessarily those of the Department, the UCLA Luskin School of Public Affairs, UCLA as a whole or the client.

ACKNOWLEDGMENTS

We would like to thank Professor John Villasenor for his insight, guidance, and support as our advisor for this project. We would also like to express our appreciation for the additional research guidance from Professor Manisha Shah, Professor Aaron Panofsky, Professor Meredith Phillips, and Professor Randall Akee from the UCLA Luskin School of Public Affairs; and Professor Noreen Webb and Professor Matthew Madison from the UCLA Graduate School of Education and Information Studies.

We would also like to show our gratitude to Ryan Chan and the office of Institutional Research and Academic Planning at the University of California, Office of the President for their patience and support as our client for this policy project.

We are deeply grateful to Dean Jayathi Y. Murthy of the UCLA Henry Samueli School of Engineering and Applied Science for sharing her vision for the engineering program and providing valuable first-hand insights for our project. Additionally, we are thankful to Dr. Gershon Weltman, Ms. Kate Lehman, and Ms. Kimberly Peterson for providing expertise from their respective fields. We also thank the female undergraduate engineering and computer science students interviewed for this report for sharing their experiences with our team.

Thank you to our peer reviewers, Elizabeth Canales, Emma Huang, and Regem Corpuz for providing thoughtful and constructive feedback on this report throughout the quarter.

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EXECUTIVE SUMMARY

Stark gender disparities in engineering, professional and academically, suggest that cracks still exist in the pipeline for female engineers. We find that despite public and private investment and national calls for action, numbers have remained stagnant. A key concern for policymakers and advocates, then, is identifying where the system falls short of retaining women engineers. Our project looks at retention performance in the University of California system, the leading producer of engineers in the state.

At the interest and request of our client, the University of California, Office of the President, our project team analyzed the system-wide performance in engineering retention at the undergraduate level by gender, and identified programs and policies that have shown to increase the rate of retention for female students. We found that the four-year retention rate for the female UC engineering students in our sample was *eight percentage points* lower than their male classmates, indicating that in addition to low enrollment rates, lower retention rates also pose a barrier to graduating more female UC engineers.

While examining factors that may explain why rates might differ by gender, we identified recurring themes from a review of academic literature, and interviews with students, experts and stakeholders. Our findings include:

- ***Female and male students exhibit similar levels of academic performance in the first year of the program***

  Consistent with the literature, we did not find a statistically significant difference in the grade point averages of female and male engineering students in the first year of the program. While female students enter the program, on average, with higher high school grade point averages and slightly lower SAT Math scores, academic performance evens out by the end of the first year. Given the fact that first-year performance is a strong indicator of retention, the lack of difference in first-year GPA suggests that academic ability does not account for the gender disparity.

- ***Female students may be more prone to feeling a lack of "engineering identity"***
  Being outnumbered by male students may make it harder for female students to identify with being an engineer. Research finds that identification with a field of study is found to be an important factor in a student's decision to continue with a major. Students interviewed noted that affinity groups play a key role in affirming engineering identity and belonging in the field.
- ***Early, theoretical coursework can lead to a loss of interest in the field***
  Early coursework in the first years of the program may run counter to the hands-on, application-based programs designed to encourage K-12 students to enter STEM fields. As a result, students early in their program may question their interest and ability to succeed in the field. Though this can apply to female and male students, research finds that women are more likely to be drawn to the potential for social impact in their work, indicating that real-world application may be a greater motivator for field persistence for women.

We selected policy options that directly addressed the major themes we found in our research, particularly surrounding engineering "fit". Each option was evaluated on anticipated effectiveness, cost feasibility and institutional feasibility. Our policy recommendations fall under two major themes:

- ***Provide support for female students; encourage a sense of community and belonging***

  We recommend that all engineering programs consider adopting residential living communities and formal peer mentoring programs for its female undergraduate students. Both have the potential to provide new female freshmen with immediate support networks, thus increasing the likelihood of identity cultivation early in the program. The increases in system-wide student enrollment and proposed housing make these two programs prime for consideration.

- ***Need to recognize and assess the diversity climate for underrepresented students***

  Second, we encourage assessments of current support programs and student perceptions of the diversity climate through diversity task forces within engineering programs. In addition, we encourage programs to actively incorporate diversity awareness into their core curriculum. Doing so, we believe, can be a step toward the acknowledgement and understanding of the value of diversity in the field and the implicit biases that discourage identify formation in underrepresented students. This approach removes the burden of raising awareness off of underrepresented students themselves and can help develop the next generation of socially-conscious engineers.

We find that the time is right for greater action on this issue by both UCOP and campuses systemwide. Recent successes in the field are providing momentum for greater evaluation and adoption of retention initiatives that focus both on added support and large-scale institutional change. Further, in California, increases in UC enrollment offer campuses a window of opportunity to promote and implement programmatic changes that can foster a supportive environment for female engineers. With hopes that enrollment increases will lead to a higher number of women in the program, we feel strongly that engineering programs must prioritize and focus on the support and retention of future women engineers.

INTRODUCTION: WOMEN IN ENGINEERING

Advancing technology and innovation through the development of a highly-skilled, tech-savvy workforce is recognized as a crucial driver for economic growth and global competitiveness. California, as a leader in the field through its high-tech sector and world-class academic institutions, is at the forefront of cultivating the next generation of innovators and industry leaders. Reports find that the state will need to fill 1.1 million jobs in Science, Technology, Engineering and Math (STEM) by 2018, with almost a third of jobs in engineering.[1] While demand for engineering talent continues to rise, a look at the workforce today shows little headway in gender diversity, indicating a massive pool of untapped talent at the state and national levels.

While women have made advancements toward gender parity in traditionally male-dominated professions, gains in engineering have remained modest and representation has been slow relative to other STEM professions such as medicine and chemistry. In 2013, women made up only 12% of practicing engineers in the U.S.[2] Researchers have described the field "as the most sex-segregated non-military profession in the world".[3]

Why Female Representation Matters

Lower levels of female representation have reverberating effects on the quality of output in the field, the experiences of women in engineering and computing sectors, and the pipeline that encourages a new generation of female engineers. As a result of the low proportion of

[1] Carnevale, Anthony P., Nicole Smith and Michelle Melton. STEM: State Level Analysis. *Georgetown University*, 2014. Accessed January, 15, 2017

[2] "Solving the Equation: The Variables for Women's Success in Engineering and Computing", *American Association of University Women*, 2015. Accessed January 15, 2017

[3] Cech, Erin et al.,"Professional Role Confidence and Gendered Persistence in Engineering", *American Sociological Review*, September 28, 2011. Accessed January 15, 2017 doi: 10.1177/0003122411420815

women in the field, the “experiences, opinions and judgments” of half the population are missing from the technology that drives everyday human interactions, and the innovative work aimed at addressing some of the major societal challenges of the day.[4]

Unsurprisingly, women, as professionals, stand to miss out as well. The American Association of University Women finds that in addition to higher average starting salaries, careers in engineering may offer greater opportunities for work flexibility (e.g. working remotely), higher job satisfaction and a “substantially lower” gender gap in pay compared to other professional occupations.[5] However, the ongoing debates over the professional environment for women in technology fields, and regular reports of gender discrimination and sexual harassment in the sector challenges those findings.

One of the strongest merits of greater female representation in engineering, then, is the powerful feedback effect it can have in encouraging more women to enter the field, by breaking down deep-seeded misconceptions -- which can be held by both genders -- that the field is solely for men.[6]

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[4] “Solving the Equation: The Variables for Women’s Success in Engineering and Computing”, *American Association of University Women*, 2015. Accessed January 15, 2017

[5] Ibid.

[6] Hill, Catherine, Corbett, Christianne, and Rose, Andresse St. “Why So Few? Women in Science, Technology, Engineering, and Mathematics”, *American Association of University Women*, February 2010. Accessed January 16, 2017

Gender Disparities at College Campuses

The gap at the professional level can be traced back to the chronic gender imbalance of engineering programs at academic institutions across the country. In 2014, women made up just 18.4% of undergraduate engineering degrees awarded at accredited colleges and universities nationwide. When measured relative to the percentage of women on college campuses, the low rate of engineering enrollment indicates the widening d*isproportionality* of gender representation. Women have continued to outnumber men in degree attainment annually since 1983, with 60% of all undergraduate degrees expected to be awarded to women this year.[7] Yet, over the past decade, rates of engineering degree attainment remain constant despite a national call for STEM preparedness, and growth in public and private investment in initiatives aimed at increasing STEM interest in young women.[8]

Attempts to advance the number of women in engineering programs traditionally target enrollment (entry) and retention (graduation). One study finds that one in 17 women entering college intend to major in engineering, compared to one in five men.[9] And though retention rates in the engineering are found to be relatively equal between men and women nationwide, any loss of female students in the program has a strong impact due to the low number of women entering programs nationwide.[10] In this report, we test to find whether rates are similarly equal at University of California campuses.

[7] U.S. Department of Education, National Center for Education Statistics,"Digest of Education Statistics 2015", December 08, 2016. Accessed January 16, 2017
[8] Ibid.
[9] "Solving the Equation: The Variables for Women's Success in Engineering and Computing", *American Association of University Women*, 2015. Accessed January 15, 2017
[10] Ibid.

FEMALE ENGINEERING AT THE UNIVERSITY OF CALIFORNIA

Client Summary: The University of California, Office of the President

The University of California, Office of the President (UCOP) is the system-wide headquarters of the University of California. Based in Oakland, CA, the office manages the administrative functions required to carry out the system's mission of serving the state of California through teaching, research, and public service.[11] Administrative responsibilities include the management of system-wide fiscal and business operations,[12] and support for the academic and research missions across its ten campuses, labs, and medical centers through the development of policy frameworks.[13] Furthermore, the office advocates and lobbies on behalf of the system to the state and federal government.[14]

The President of the UC system has "full authority and responsibility over the administration of all affairs and operations of the University"[15] except for responsibilities assigned to the Principal Officers of the Regents.[16] The president consults with the chancellors and the Academic Senate from each of its campuses regarding the university's educational and research policies as well as coordinates a single operating budget and a capital budget for the

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[11] "Our Mission." *University of California, Office of the President*. Accessed January 27, 2017. http://ucop.edu/uc-mission/index.html.
[12] Ibid.
[13] Ibid.
[14] Ibid.
[15] "University Governance and Administration," *University of California, Office of the President*, accessed February 6, 2017. http://www.ucop.edu/academic-personnel-programs/programs-and-initiatives/faculty-resources-advancement/faculty-handbook-sections/university-governance-and-administration.html.
[16] Ibid.

system.[17] The president also negotiates with the state government for the budget by permission of the Regents.[18][19]

At the campus-level, chancellors -- the executive heads of campuses -- are responsible for "the organization and operation of their respective campuses, including academic, student, staff, and business affairs; and for discipline within them."[20] While UCOP does not have authority over the management of individual campuses and campus priorities, the office, at times, issues system-wide directives in the form of Presidential Initiatives when there is a recognized need for additional resources from headquarters.[21] Recent examples include the management of sexual harassment reporting at UC campuses, and support for undocumented students in the UC system.[22][23] Yet, in most cases, campus management is left to its campus administrative bodies.

For this project, we worked with the office of Institutional Research and Academic Planning (IRAP), located within UCOP. IRAP collects data regarding all areas of operations systemwide and from each UC campus, "provides evidence-based analyses"[24] and reports advocating strategic plans, institutional policies, and decision making.[25]

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[17] "University Governance and Administration," *University of California, Office of the President*, accessed February 6, 2017. http://www.ucop.edu/academic-personnel-programs/programs-and-initiatives/faculty-resources-advancement/faculty-handbook-sections/university-governance-and-administration.html.

[18] King, C. Judson. "Tailoring Shared Governance to the Needs and Opportunities of the Times." *Research and Occasional Paper Series: CSHE.* 13. 13. (2013): 3.

[19] King, C. Judson. "On the Apportionment of Administrative Governance Functions within Multi-Campus Universities and University System." *Research and Occasional Paper Series: CSHE.* 16.13. (2013): 3,5

[20] "University Governance and Administration." *University of California, Office of the President*. Accessed February 6, 2017. http://www.ucop.edu/academic-personnel-programs/programs-and-initiatives/faculty-resources-advancement/faculty-handbook-sections/university-governance-and-administration.htm.

[21] Peterson, Kimberly. Interview by Traci Kawaguchi. UCLA, March 1, 2017.

[22] Peterson, Kimberly. Interview by Traci Kawaguchi. UCLA, March 1, 2017.

[23] Freedberg, Louis. "University of California President Emerges as Champion of Program for Undocumented Students." *EdSource*. Accessed March 17, 2017. https://edsource.org/2017/uc-president-emerges-as-champion-of-program-for-undocumented-students/576323.

[24] "Institutional Research and Academic Planning." *University of California, Office of the President.* Accessed February 6, 2017. http://ucop.edu/institutional-research-academic-planning/.

[25] Ibid.

Undergraduate Female Engineers in the UC System

With the continued demand of jobs requiring STEM degrees in California,[26] the UC system is expected to play a leading role in producing the next wave of talent to keep the state globally competitive. Noticeable, however, is the gender imbalance in STEM students and graduates, which in turn is reflected in the chronic gender gap that exists in the science and engineering workplace. Therefore, critical to meeting its mission is the importance of UC addressing gender diversity in STEM fields at its undergraduate campuses.

In 2014, approximately 44 percent of UC undergraduate students enrolled in STEM (i.e engineering/computer science, life sciences, and physical sciences) were women, compared to 60 percent of female undergraduates in non-STEM fields, including undeclared students.[27] When we consider STEM majors individually, however, we see large variations in female representation by field. (Figure 1).

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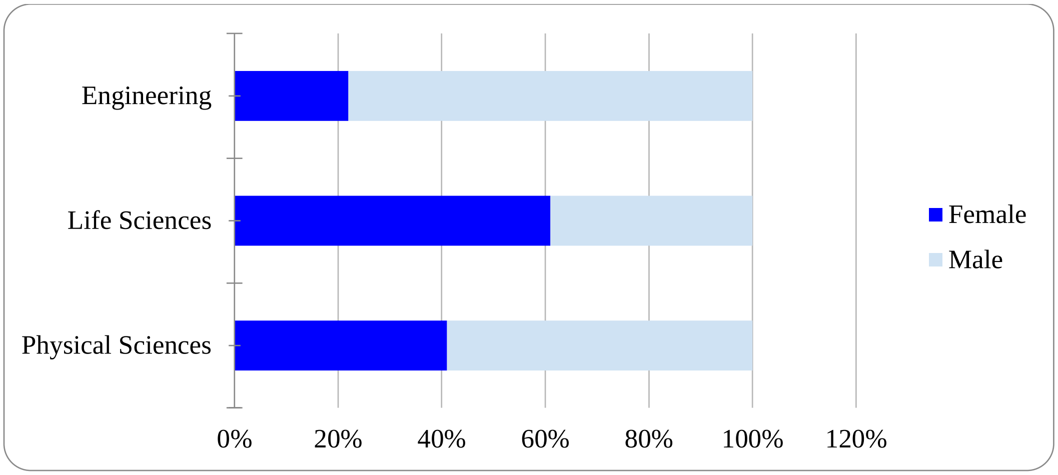
[26] Carnevale, Anthony P., Smith, Nicole., and Melton Michelle. "STEM: State Level Analysis." *Georgetown University Center on Education and the Workforce.* (2014): 16

[27] "Fall Enrollment Headcounts." *University of California*. Accessed January 27, 2017. https://www.universityofcalifornia.edu/infocenter/fall-enrollment-headcounts.

Figure 1: UC Undergraduate Enrollment in STEM Fields by Gender, 2014



Data Source: University of California Office of the President, "Fall Enrollment Headcounts"

Within STEM fields, women enroll at considerably lower rates in engineering relative to the life and physical sciences. While female students made up 61 percent of life science and 41 percent of physical science students, they made up only 22 percent of engineering students.[28] By rates of degrees awarded by gender, female engineering bachelor's degree recipients at UC were also significantly underrepresented —20 percent in engineering, as opposed to 58 percent in life science, and 39 percent in physical science.[29] These trends have remained consistent over the past five years.[30][31]

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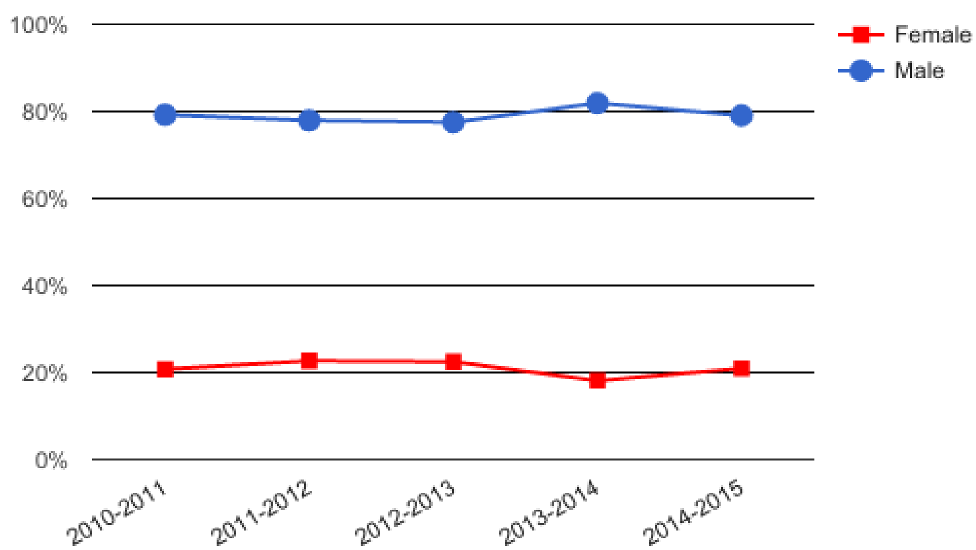
[28] "Fall Enrollment Headcounts." *University of California*. Accessed January 27, 2017. https://www.universityofcalifornia.edu/infocenter/fall-enrollment-headcounts.

[29] "Degrees Awarded Data." *University of California.* Accessed January 27, 2017. https://www.universityofcalifornia.edu/infocenter/degrees-awarded-data.

[30] "Fall Enrollment Headcounts." *University of California.* Accessed January 27, 2017. https://www.universityofcalifornia.edu/infocenter/fall-enrollment-headcounts.

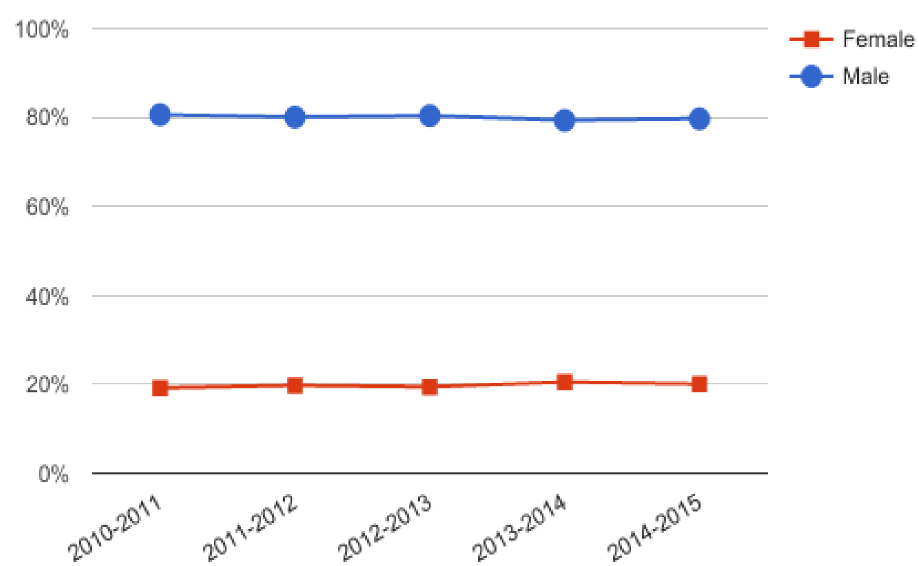
[31] "Degrees Awarded Data" *University of California.* Accessed January 27, 2017. https://www.universityofcalifornia.edu/infocenter/degrees-awarded-data.

Figure 2: UC Undergraduate Enrollment in Engineering by Gender, 2010-2014



Data Source: University of California Office of the President, "Fall Enrollment Headcounts"

Figure 3: UC Bachelor's Degrees in Engineering Awarded by Gender, 2010-2014



Data Source: University of California Office of the President, "Degrees Awarded Data"

When we compare UC performance in producing female engineers nationally, we find that while UC campuses produce some of the highest total engineering degree numbers in the country, their rates of female enrollment trail other schools. (See Appendix A)

In 2014-2015, UC San Diego and UC Berkeley were ranked among the top 15 schools in the total number of bachelor's degrees in engineering awarded to women.[32] (See Appendix A) When measured by the percentage of engineering degrees awarded by gender, not one UC campus made the top 20.[33] (See Appendix B) At institutions ranked, the proportion of engineering degrees awarded to women ranged from 30-50%.[34] With the exception of one campus, all institutions listed are private institutions. In comparison, among UC engineering programs, female undergraduate enrollment and degree distribution rates range from roughly 10 to 20 percent.[35]

While UC performance female engineering enrollment is on par with the national average of 20%,[36] we find that the system has room for improvement in its female enrollment relative to leading institutions. Campuses have shown that reaching gender parity in engineering representation is a possibility.

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[32] Yoder, Brian L. "Engineering by The Numbers." *American Society for Engineering Education (ASEE)* (2015): 15. Accessed January 23, 2017. https://www.asee.org/papers-and-publications/publications/college-profiles/15EngineeringbytheNumbersPart1.pdf.
[33] Ibid.
[34] Ibid.
[35] "Fall Enrollment Headcounts." *University of California.* Accessed January 27, 2017. https://www.universityofcalifornia.edu/infocenter/fall-enrollment-headcount.
[36] Yoder, Brian L. "Engineering by The Numbers." *American Society for Engineering Education (ASEE)* (2015): 15. Accessed January 23, 2017. https://www.asee.org/papers-and-publications/publications/college-profiles/15EngineeringbytheNumbersPart1.pdf.

Current UC Campus Programs Focused on Recruitment and Retention of Female Engineers

Engineering programs at UC campuses statewide have introduced initiatives and programs focused on the recruitment and retention of young women into their engineering programs. A sample of programs are below:

- According to Dean Jayathi Y. Murthy of the UCLA Engineering school, UCLA is currently in the early stages of creating **Women in Engineering office** in the program, which will support female student outreach, retention and career development for female students in the programs.[37] The move is motivated by the low numbers of women in the program, as well the increase in expected student enrollment.[38]
- The **Leadership in Engineering Advancement, Diversity and Retention (LEADR)** program at UC Davis aims to create a diverse student body in engineering through a targeted focus on recruitment and retention.[39] The program offers a wide range of support for underrepresented students including academic advising, workshops, leadership skills development and graduate school preparation, which are offered and supported by the other campus units involved.[40] Additionally, **the LEADR Student Center**, which opened with sponsorships from leading tech firms, provides an open study space that encourages regular interaction and creates a welcoming environment for students.[41]
- **Project AWESOmE** (Advancing Women's Education in the School of Engineering) was developed by UC Santa Cruz's engineering school, in partnership with the National

[37] Murthy, Jayathi Y. Interview by Traci Kawaguchi, Yuhan Sun, and Eri Suzuki. UCLA, March 13, 2017.
[38] Murthy, Jayathi Y. Interview by Traci Kawaguchi, Yuhan Sun, and Eri Suzuki. UCLA, March 13, 2017.
[39] "LEADER Program." *UC Davis College of Engineering.* Accessed February 25, 2017. http://engineering.ucdavis.edu/undergraduate/leadr-advising/.
[40] Ibid.
[41] "LEADER Student Center." *UC Davis College of Engineering.* Accessed February 25, 2017. http://engineering.ucdavis.edu/undergraduate/leadr-student-center/.

Center for Women and Information, as part of a strategic plan for fostering an environment that emphasizes mutual ambition, support, and empowerment.[42] Project AWESOmE organizes various programming on campus including guest speaker events, a mentoring program for incoming freshmen women, and technical and professional workshops designed to connected students to the professional field.[43]

- **CS KickStart** at UC Berkeley targets incoming female students interested in computer science for a one-week crash course on computing and campus life prior to the start of the school year.[44] The curriculum includes opportunities for hands-on application of concepts learned in the program, as well as opportunities to meet with alumni in the industry and a visit to a Silicon Valley tech company to see computing work in action.

UCOP Motivation to Deal with Retention

Despite great interest and investment in the issue, data shows that the gender gap in STEM in the UC system has been consistent over the past five years. With respect to STEM fields, one can argue that the University of California has not achieved its mission[45] and diversity statement[46], a commitment to serving the diverse needs of California and striving for diversity within its student body, faculty, and employees.[47] Thus, our work with UCOP on gender disparities is an effort to see how the system can better meet its stated mission.

[42] Stephens, Tim. "UCSC's 'Project Awesome' Supports Women in Computing." *University of California, Santa Cruz Newscenter.* (2014) Accessed February 25, 2017. http://news.ucsc.edu/2014/03/project-awesome.html.

[43] "Project AWESOmE: Advanced Women's Education in the School Of Engineering." *UC Santa Cruz, Baskin Engineering.* Accessed February 25, 2017. https://awesome.soe.ucsc.edu/.

[44] "CS KickStart." *UC Berkeley.* Accessed March 17, 2017. https://cs-kickstart.berkeley.edu/index.html.

[45] "Our Mission." *University of California, Office of the President.* Accessed January 27, 2017. http://www.ucop.edu/mission/index.html.

[46] "Regents Policy 4400: Policy on University of California Diversity Statement." *University of California, Board of Regents.* Accessed February 25, 2017. http://regents.universityofcalifornia.edu/governance/policies/4400.html.

[47] "Our Mission." *University of California, Office of the President.* Accessed January 27, 2017. http://www.ucop.edu/mission/index.html.

While there are several approaches to increasing the number of STEM students UC graduates from its programs, for the purposes of this project, UCOP has a particular interest in student retention -- as opposed to recruitment -- due to the potential for institutional approaches and the availability of data on enrolled students. Including recruitment in the context of improving gender diversity would broaden the scope of the project to include K-12 education and require data on potential students which the system does not have. Further, actions taken to address retention in the UC system are contingent on action within the system itself with limited influence from outside parties. Therefore, it is easier to evaluate or anticipate the effectiveness and feasibility of implementing policy options.

In addition to retention, our project focuses on the field of engineering. Due to the time and resources constraints, we concentrate solely on engineering field where gender disparities are among the greatest and where demand for STEM jobs is one of the highest. Consequently, this project will be focused on gender diversity in engineering in terms of retaining female undergraduate students.

The main goal for our project is to determine the factors that have an impact on gender inequality in engineering and provide policy options for engineering programs to address the issue. Ultimately, this project can serve as a starting point for UCOP advocacy efforts to obtain state and federal resources aimed at increasing female engineering presence in UC, further meeting the system's mission of diversity and contributing to the benefit of California's economy and its people.

POLICY PROBLEM / POLICY QUESTION

Our team used data provided by our client to analyze the rate of retention in UC engineering programs, and identify disparities between female and male students. The provided dataset is a randomized sample of engineering students from seven of the nine UC undergraduate campuses.[48] The sample population for this project, n=2471, is comprised of female and male undergraduate students entering UC engineering programs as freshmen from Fall 2008-Fall 2010. The dataset is weighted to account for proportional representation by campus. To determine retention rates, students were identified as staying in or leaving the program based on the degree conferred by the university. Students identified as "stayed" were awarded an engineering degree, whereas students who "left" were either awarded a degree in a non-engineering field or were not awarded a degree by the university. We determine engineering as a field based on the Classification of Instructional Programs (CIP) code for the field of study.[49]

For the purposes of this report, we calculate the retention rate as the percentage of undergraduate students entering the engineering field as freshmen who were eventually awarded their engineering bachelor degree.

Results

We find that the retention rate for engineering students in the sample is 62.7%. When broken down by gender, 56.3% of female students entering the engineering program graduated

[48] Data from UC Merced and UC Santa Cruz are not included in the dataset

[49] Due to variation in the placement of Computer Science among the Schools of Engineering and the separate classification by Classification of Instructional Program code, students who switch from engineering to computer science are counted as "leaving" the program.

from the program, compared to 64.7% of male students. Data on national engineering retention rates in total and by gender were not available.

Table 1: Retention Rates for Undergraduate Students in UC Engineering Programs, by Gender (Students Entering Fall 2008-2010)[50]

	Graduated from the Engineering program	Left the Engineering program
Female	56.3%	43.7%
Male	64.7%	35.3%

Data Source: Office of Institutional Research and Academic Planning, UCOP

Female students graduated from the program at a rate eight percentage points lower than male students. The findings illustrate that not only are female students *entering* UC engineering programs at substantially lower rates than male students, they are also *leaving* engineering at a higher rate, revealing gender disparities in both enrollment and retention.

Low retention rates can indicate both personal and institutional factors that inhibit students from continuing with the program. Disparities in the two rates also indicate that the attrition factors may vary by gender. Therefore, understanding how the UC system can improve the learning environment for engineering students can help the system make strides toward decreasing the attrition rate for women, closing the gap between men and women, and increasing the number of women graduating from UC engineering programs. This leads our policy question:

[50] Students that graduate from the engineering program (based on CIP codes) are indicated as "staying" in the program. Students who graduate with a degree other than engineering, or leave the school are indicated as "leaving" the program.

What programs and policies can the University of California implement or recommend to create an environment that encourages female undergraduate retention in the engineering field?

METHODOLOGY

Given the substantial body of work in the field, the aim of this report is to provide our client with 1) an assessment of UC performance in retention, 2) an overview of current discussions and efforts noted in the literature, and 3) policy recommendations drawn from findings and best practices in the field. While the report examines system-wide performance based on data provided by our client, our analysis of campus climate is heavily focused on the UCLA Henry Samueli School of Engineering and Applied Science. Four methods of research were employed for the report:

A. Quantitative Analysis

Our client provided a randomized sample of UC undergraduate engineering students from seven out of the nine undergraduate institutions. The sample is comprised of undergraduate students entering engineering programs as freshmen from Fall 2008-Fall 2010. After administering weights for proportional representation by campus, the sample size was n=2471. In addition to calculating retention rates, we used the dataset to test for effects of various independent variables on our outcome of interest, retention.

Research Design

First, we conducted means and proportion comparisons to test for variances between the sample female and male populations. Next, we used a logistic regression to determine the effect of gender, academic performance and family background on retention, the response variable. In addition, we tested the interactions between gender and academic performance, and gender and race to test whether the variables of interest have different impacts on the probability of female students remaining in the program relative to their male peers. We identified and controlled for following variables which have shown to have an effect on student retention:

Race: African American, Asian, Hispanic, White, and Other[51]

Data from National Center for Education Statistics shows while the retention rate for White, African American, and Hispanics students increased from 1997 to 2007, rates varied by race. The retention rate was higher for White and African American students than for Hispanic students.[52] The retention rate for Asian/Pacific Islander students was also higher than the rate for Hispanic and Black students.[53]

Family Background: First Generation[54] and Family Income

Information on family background includes status as a first-generation college student and family household income. Studies show that the level of parental postsecondary education has a significant impact on both academic and non-academic experiences in college.[55] Students with parents with postsecondary degrees may be more aware of how important an advanced degree can be in the labor market than first-generation students.[56] In addition, students from

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[51] For our analysis, "other" includes American Indian/ Alaska Native, Native Hawaiian/Other Pacific Islander, and students who identified two or more races.

[52] Aud, Susan, Fox, Mary A., and KewalRamani, Angelina KewalRamani. "Status and Trends in the Education of Racial and Ethnic Groups." *National Center for Education Statistics. NCES 2010-2015*, July 14, 2010.Accessed March. 05, 2017 https://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2010015.

[53] Ibid.

[54] First-generation college student: a student whose parent(s)/legal guardian(s) have not completed a bachelor's degree. This means that you are the first in your family to attend a four-year college/university to attain a bachelor's degree; "Are you a First Generation college student?" Accessed March 05, 2017. https://www.chapman.edu/students/academic-resources/first-generation/

[55] Pascarella, Ernest T., Pierson, Christopher T., Wolniak. Gregory C., and Terenzini, Patrick T. "First-Generation College students: Additional Evidence on College Experiences and Outcomes." *The Journal of Higher Education*, Volume 75, Number 3 (2004): 249-284 Accessed March 05, 2017. doi: 10.1353/jhe.2004.0016

[56] Ibid.

families with lower household incomes were found to spend time on part-time employment, which may have a negative influence on retention.[57]

Academic Performance: High School GPA, SAT Math scores, and First Year GPA

Research shows that high school GPA is one of the best predictors of student performance in college.[58] We selected SAT Math scores as an indicator of math performance, which we found relevant given the importance of math competency to engineering studies.[59] Studies also find that the majority of engineering students who drop out performed poorly in their first year, indicating an inverse relationship between the probability of retention and first year GPA, therefore we include first year GPA.[60]

Limitations: We recognize a number of limitations based on the size of our dataset and the method by which data was collected. First, given the small number of observations for subsets of students, such as African American engineering students, findings cannot be generalized to the population at the UC system-wide level. Second, in this sample, family income is self-reported by applicants, instead of collection through more formal means. Third, we recognize that the availability of Advanced Placement courses varies by schools and may

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[57] Tinto, Vincent. "Student retention and graduation: Facing the truth, living with the consequences." *Pell Institute for the Study of Opportunity in Higher Education* (2004) Accessed March 5, 2017. http://files.eric.ed.gov/fulltext/ED519709.pdf.

[58] Geiser, Saul and Santelices, Maria V., "Validity of High-school Graduates in Predicting Student Success Beyond the Freshman Year: High-School Record vs. Standardized Tests as Indicators of Four-Year College Outcomes", *Research & Occasional Paper Series: CSHE.*6.07 (2007). Accessed March 5, 2017. http://files.eric.ed.gov/fulltext/ED502858.pdf.

[59] Asshaari et al., "The Importance of Mathematical Pre-University in First Year Engineering Students", *Elsevier Ltd. Selection*(2011):372-377, accessed March 5, 2017. http://ac.els-cdn.com/S1877042812038487/1-s2.0-S1877042812038487-main.pdf?_tid=857939a4-0210-11e7-b605-00000aab0f26&acdnat=1488765744_31e9e7b1253ee7b9af26a9f3b666ef3f.

[60] Harrison, Roger et al., "Report on Findings about Undergraduate Student Graduation and Retention." Accessed March 5, 2017. http://www.ou.edu/admin/facsen/minutes/reten.htm.

have an effect on grade point averages depending on which school the student attended. For example, at schools with more opportunities for AP coursework, grade point averages may be higher due to the ability to take more weighted AP classes.

B. Literature Review

We conducted a literature review in order to:

1) Gain background information about female's retention in STEM fields
2) Understand the current situation of retention in engineering schools at the UCs
3) Identify factors that have impacts on attrition of female students in engineering fields
4) Develop policy alternatives by learning good practices both inside and outside the UC system
5) Find evidence that can be used for evaluating policy alternatives

Our main sources for the literature review are online journals, research reports produced by educational institutions, and books on women and retention. For best practices and examples of retention programs, we utilized reports and web information from engineering program websites.

C. Interviews

Our team conducted in-depth interviews with female undergraduate students currently enrolled in engineering and computer science programs at UCLA. Student interviewees were recruited through the assistance of Professor John Villasenor and through the list serves of UCLA affinity groups for engineering women including Women Advancing Tech through

Teamwork (WATT) and the Society of Women Engineers at UCLA. Student interviews were conducted one-on-one on campus, and at student group functions.

In addition, our team conducted interviews with stakeholders and experts to learn more about present efforts to address gender inequity in engineering. As with student interviews, non-student stakeholder interviews provided information that assisted in the determination of policy alternatives.

Limitations: Given the handful of students interviewed for the project, we understand that their experiences do not capture the experiences and perspectives of all students in the program. Further, our strategy of recruitment through student groups lead to the natural selection of students who are actively involved in student groups and who benefited from the resources provided. We recognize that this is not the case for all female students. In addition, our interviews include students from the computer science department which we do not include in our earlier retention assessments. However, given the department's placement in the engineering school at UCLA and parallels in experience, their interviews were valuable in providing student perspective.

D. Observational Study

We conducted observational research at one student meeting and one workshop held by WATT. Through attendance at these events, we were able to observe the types of programming student groups offered and how they are conducted in practice. The events also allowed our team to conduct further interviews with students involved in WATT in addition to workshop participants to learn how they see the roles of student groups in the program, and how they perceive the climate at the engineering school.

FINDINGS

Analysis of UCOP Data

Gender disparities persist despite even academic performance between female and male engineering students

Summary: A preliminary look at student data finds disparities in retention rates by gender, with women leaving the program at higher rates than men. When we control for race, family background and academic performance, we find that the odds of female students staying in the program are *30 percent lower* than that for male students, supporting our earlier finding.

When testing academic indicators, female students, on average, entered UC engineering programs with higher high-school GPAs and slightly lower SAT math scores than male classmates. However, academic performance evens out in the first year of the program. Between female and male students, we did not find a statistically significant difference in first-year GPA. Further, though academic performance in high school and freshman years is positively associated with higher odds of retention for all students, there was not a statistically significant difference on the effect of performance on retention by gender. Consistent with the literature, we can infer that the disparity in retention is not likely driven by academic performance and, instead, may be associated with unobservable characteristics (e.g. external factors).

Descriptive Data

Table 2: Academic Performance of UC Engineering Students by Gender (Weighted)

Academic Performance Indicators	Gender						95% CI for Mean Difference			
	Female			Male						
	M	SD	N	M	SD	N			t	df
High School GPA	3.99	.32	593	3.92	.34	1878	.03	.09	3.93***	2469
SAT Math	649.64	93.69	593	677.26	85.56	1878	-36.13	-19.10	-6.36***	2469
First-Year GPA	2.98	.52	593	2.99	.53	1878	-.049	.047	-.04	2469

Data Source: Office of Institutional Research and Academic Planning, University of California Office of the President
$*p<.05$ $**p<.01$ $***p<.001$

Academic Performance

On average, female engineering students had higher high school GPAs but scored lower on the SAT Math exam than male students upon entering the engineering program. Both findings were statistically significant at the 0.001 level. By the end of the first year of the program however, we do not find a statistically significant difference in the average performance of female and male students.

Table 3: UC Engineering Student Populations by Race, Gender (Weighted)

	Female		Male		Total	
	Obs.	**%**	**Obs.**	**%**	**Obs.**	**%**
Race						
African-American	14	2.4	26	1.4	40	1.6
Asian	294	49.6	927	49.4	1,221	49.4
Hispanic	114	19.3	324	17.3	438	17.7
Other	14	2.4	55	2.9	69	2.8
White	157	26.3	546	29.0	703	28.5

Data Source: Office of Institutional Research and Academic Planning, University of California Office of the President

Race

We also find that rates of enrollment by race are similar within the female and male engineering student populations. Roughly a majority of female students are Asian (49.6%), followed by White and Hispanic (26.3% and 19.3% respectively). Both African American female students and female students categorized in the Other category had same percentage of enrollment (2.4%) in engineering programs. Rates are consistent in the male population, with the exception of African American male students, who are represented at lower rates than African American female students.

Data Analysis

To determine the probability of student retention, we ran a logistic regression in which we regressed the probability of retention on independent variables including gender, race, family background and academic performance (Table 4). We further tested the interactions of gender and performance to measure the effect of gender on our academic indicators (Tables 5, 6), and race (Table 7). All outputs are represented in odds ratios.

Table 4: Odds Ratios for Retention by Gender, Race, Family Background and Academic Performance

Predictor	OR	S.E.	Sig
Female	.693	.078	.001***
African American	.916	.351	.820
Hispanic	1.343	.187	.035*
Other	.719	.216	.273
White	.982	.115	.880
First Generation	.843	.100	.153
Income	1.066	.064	.284
HS-GPA	2.297	.364	.000***
SAT-Math	1.004	.001	.000***
Year1GPA	3.742	.422	.000***
Constant	.000	.000	.000***

Data Source: Office of Institutional Research and Academic Planning, University of California Office of the President
Note: Leave=0 Stay=1; Male=0 Female=1; Not First Generation=0 First Generation=1
Asian is the reference category
$*p < 0.05$, $**p<0.01$, $***p<0.001$

Results reaffirmed that gender has significant impact on retention, with the odds of women leaving the program .69 times the odds of their male peers, holding other variables constant. When we go further into the academic performance between two groups, we find that that there is not a statistically significant difference in the *effect* of academic performance on retention by gender (Table 5, 6).

Table 5: Odds Ratios for Retention by Gender and High School Academic Performance

Predictor	OR	S.E.	Sig
Female	.822	1.228	.896
HS-GPA	3.999	.682	.000***
Female x HS-GPA	.825	.315	.614
SAT-Math	1.006	.001	.000***
Female x SAT-Math	1.001	.001	.465
Constant	.000	.000	.000***

Data Source: Office of Institutional Research and Academic Planning, University of California Office of the President
Note: Leave=0 Stay=1; Male=0 Female=1
$*p < 0.05$, $**p<0.01$, $***p<0.001$

Table 6: Odds Ratios for Retention by Gender and College Academic Performance

Predictor	OR	S.E.	Sig
Female	.644	.463	.541
Year1GPA	5.889	.687	.000***
Female x Year1GPA	1.005	.247	.985
Constant	.010	.003	.000***

Data Source: Office of Institutional Research and Academic Planning, University of California Office of the President
Note: Leave=0 Stay=1; Male=0 Female=1
$*p < 0.05$, $**p<0.01$, $***p<0.001$

To determine whether retention rates varied within the female student population, we tested the interaction between female and race to determine the odds of retention within the female population by race (Table 7).

Table 7: Odds Ratios for Retention by Race and Gender

Predictor	OR	S.E.	Sig
Female	.682	.098	.008***
African American	.802	.447	.693
Female x African American	.255	.183	.056
Hispanic	.459	.107	.001***
Female x Hispanic	1.357	.365	.256
Others	.603	.353	.387
Female x Others	1.915	1.267	.326
White	1.505	.326	.059
Female x White	.689	.170	.130
Constant	2.02	.146	.000***

Data Source: Office of Institutional Research and Academic Planning, University of California Office of the President
Note: Leave=0 Stay=1; Male=0 Female=1
Asian is the reference category
$*p < 0.05$, $**p<0.01$, $***p<0.001$

When we look at the interaction between gender and race on retention, we found that there is not a statistically significant difference in the effect of race on retention by gender. Although female African American students have a significant difference ($p<.1$) from the reference group (male Asian students) on persisting in the engineering program, because of the sample size limitation of female African American students (n=14), further step analysis is needed.

Overall, by controlling relevant environmental factors that affect retention, we found that gender still has a significant impact on student retention. Furthermore, by testing the interaction between gender and relevant indicators, we found that the effect of gender is not impacted by other independent variables. Next, we turn to academic literature and interviews to identify potential environmentally-based, unobservable factors that may lead to attrition in women.

Commonly-Identified Causes of Attrition

Lower Levels of Self-Confidence in Ability to Succeed in Program

Research finds that female students are more likely to switch out of engineering during the first two years at college due to lower self-confidence in their ability to perform academically.[61] This is particularly acute for "high-achieving" women, who excelled in coursework in prior to enrollment.[62] Part of the perception can be linked to campus climate. According to Kate Lehman, research manager for the Building, Recruiting, and Inclusion for Diversity (BRAID) Research[63], female students may feel uncomfortable surrounded by competitive male students, who may act in ways that are discouraging to female students. Some male students, for example, may ask questions unrelated to class materials to demonstrate how well they know the field beyond course teachings. That specific type of behavior is likely to

[61] Brainard, Suzanne G., and Linda Carlin. "A Longitudinal Study of Undergraduate Women in Engineering and Science." *Frontiers in Education Conference.* (1997): 6.

[62] Ibid.

[63] The BRAID Initiative, launched in 2014, is a consortium of 15 computer sciences programs nationwide committed to increasing the percentage of women and students of color in computer science. BRAID Research is the research arm of the initiative, and is currently conducting a longitudinal study of the effectiveness of various interventions at BRAID participants.

affect female students' confidence because they are more likely to enter STEM fields with less experience than male classmates.

Another cause of insecurity is a misperception of ability. One study finds that a female student's threshold for failure is likely to be lower than their male classmates.[64] If a female and a male student both receive a "B" in a course, they are likely to react differently. Female students are more likely to consider a "B" as sign a lack of understanding of course material and consider switching their majors, whereas male students are more likely to the view the grade as an indicator of their ability to succeed in difficult course, according to Lehman. Further, she notes, the use of grading curves contributes to a more competitive environment that may motivate men and women differently.

Lack of "Engineering" Identity

Whether a student identifies with a field can be a strong indicator of whether they select a given major.[65] For women in male-dominated fields, in particular, the environment may make it more difficult to develop a feeling of personal association with the field. Therefore, a decision to leave a field may be motivated by a sense of a lack of belonging.[66] Cech et. al (2011) find that factors such as "expertise confidence" and "career fit" were strong indicators of persistence for female and male students. The notion of belonging was repeated in our interviews with students.

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[64] Lehman, Kate. Interview by Traci Kawaguchi and Eri Suzuki. UCLA, February 15, 2017.
[65] Ibid.
[66] Cech, Erin et al.,"Professional Role Confidence and Gendered Persistence in Engineering", *American Sociological Review*(2011):641-66. Accessed February 2, 2017, doi: 10.1177/0003122411420815.

Loss of Interest in the Field Early in the Program

A loss of interest in science and engineering is one of the most common reasons why female students switch out of the engineering field, according to a University of Washington study.[67] While lower confidence can be a trigger for a switch, the researchers suggest that one underlying cause could be how the engineering curriculum is structured.

Faculty Engagement Matters

The quality of faculty interactions is another crucial factor in student retention. One reason why female students switch out of engineering programs is the less approachable behavior faculty members may exhibit toward students.[68] One study finds that quality engagement is particularly important in male-dominated fields as it can reduce the vulnerability of female students and retain them in the field.[69] Relative to male students, female students are more likely to value building relationships with faculty members due to the positive impact these relationships can have in improving their level of confidence and self-perception in their academic performance.[70]

During the interviews, several female students noted that it was sometimes difficult to reach out to faculty in the program because they seem to be busy with their research.[71][72] In addition to one-on-one guidance, greater faculty engagement with student groups through direct

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[67] Brainard, Suzanne G., Laurich-McIntyre, Suzanne., and Carlin, Linda. "Retaining Female Undergraduate Students in Engineering and Science: 1995 Annual Report to the Alfred P. Sloan Foundation." *Journal of Women and Minorities in Science and Engineering* 2.4. (1995): 263. Accessed February 2, 2017 doi:10.1615/JWomenMinorScienEng.v2.i4.50

[68] Seymour, Elaine. and Hewitt, Nancy M., *Talking About Leaving: Why Undergraduates Leave the Science* (Westview Press, 1997), 267

[69] Margolis, Jane. and Fisher, Allan., *Unlocking the Clubhouse: Women in Computing* (The MIT Press, 2002), 89

[70] Seymour, Elaine. and Hewitt, Nancy M., *Talking About Leaving: Why Undergraduates Leave the Science* (Westview Press, 1997), 267

[71] Computer Science Student. Interview by Traci Kawaguchi and Eri Suzuki. UCLA, February 3, 2017.

[72] Computer Science Student. Interview by Traci Kawaguchi and Eri Suzuki. UCLA, February 15, 2017.

support in student group programming (i.e. academic, research workshops) and speaking events was also encouraged by students.[73]

Student Perceptions of Campus Climate

Program Rigor Main Challenge for Students

Female students interviewed pointed to the rigor of the program and a feeling of inadequacy in their ability to understand the material, particularly in the earlier years. As top-performing students at their respective high schools, some students found the transition from high school to college discouraging at times while simultaneously feeling uneasy about asking for help. One student cited early cases of "mansplaining" by her peers as a source of discouragement. However, while students noted a feeling of being in a minority group in the classroom, there was a sense that the academic rigor of the program overall was a primary challenge - not necessarily being a woman in the class.

Theoretical Work vs. Hands-On Application - "Is this going to be me for the rest of my life?"

While many pre-college STEM programs are geared toward getting students -- particularly women -- interested in the sciences, students interviewed noted that once in college programs, early coursework may not continue to pique interest, making students question their decision to continue. Coursework with a theoretical bent, for example, can give the impression that one has to "love theory" to be an engineer, one student said. She became less interested in learning engineering as struggling with heavily theoretical-focused classes. But once she started

[73] Computer Science Student. Interview by Traci Kawaguchi and Eri Suzuki. UCLA, February 3, 2017.

hands-on activities in labs, she decided to stay in electrical engineering because she learns practical skills and sees how textbooks' knowledge apply to a real world. These activities encouraged her interests in pursuing electrical engineering.

This finding was further supported by our interview with UCLA engineering school dean Jayathi Y. Murthy. The planned office for women in the engineering program at UCLA is expected to include a research component, which, based on studies, has been found to have a positive impact on retaining female students.

Being a Newcomer to the Field

A noted challenge in the literature and in interviews with computer science students, in particular, is the role of pre-college experience in programming on self-confidence in introductory computer science courses. Computer science programs across the country have begun to take steps to modify courses by experience level, but at UCLA, students say that a lack of experience can discourage students from continuing in the program.

Diversity Climate Seen as Fair, Supportive; Emphasize Need for Awareness

Informal survey assessments by the newly-established Diversity Committee at the UCLA engineering school found that 86% of respondents (male and female students enrolled in Engineering and Society) view the campus diversity climate as neutral/fair, and fair/supportive.[74] In offering recommendations, most of the recommendations suggested by female students emphasized diversity awareness over outreach and support, and at higher rates than male students. According to the committee report, recommendations for diversity awareness included

[74] Weltman Gershon, HSSEAS Committee on Diversity. *Engineering Students' Ideas about Diversity at the UCLA Henry Samueli School of Engineering and Applied Science*

faculty awareness and an adaptation of the College of Letters and Science diversity requirement for the engineering department.[75] Our team also found an interest in diversity awareness expressed in interviews. Students cited the Letters and Science requirement, and recognized that though the structure of the program might not allow for an added course, they sensed that it would be of value since many in the program were "sheltered" and many not have the experience of being in a minority group.[76]

Factors that Keep Female Students in the Program

Support from Student Groups and Peers Critical for Persistence

> *"If you're part of a close friend group, that's what really keeps you in. Knowing so many other women in electrical engineering helped a lot."*
>
> - *Fourth-year female UCLA undergraduate student, Electrical Engineering*

All students interviewed answered that support from student groups, their friends, and female upperclassmen have been helpful for them throughout the program. In one example, student groups helped a student find other female students studying the same field. Finding other female classmates in the same field is important because it not only allows for academic support, but social support, particularly if female students feel more comfortable talking with female peers rather than male peers.

Student groups can be also helpful in connecting new students with more senior engineering students early in the program. By doing so, freshmen and sophomore students can get advice on which classes they should choose from junior and senior students. They also can gain mentoring support from upperclassmen, which is provided and facilitated by student groups.

[75] Ibid.
[76] Electrical Engineering Student. Interview by Traci Kawaguchi and Eri Suzuki. UCLA, December 8, 2016.

Student groups also provide support that the engineering program and individual departments may not readily offer. One student said that student groups helped her with career development through resume and interview workshops, and career fairs specifically for female engineering students. The student group, WATT holds workshops that provide engineering students, both female and male, with basic engineering hands-on activities and skills. Furthermore, events held by student groups encourage a sense of belonging in female students, particularly freshmen. The Society of Women Engineers at UCLA hosts a stayover program the day before the program's Open House event for incoming students to encourages relationship building among incoming female students as well as with current female engineering students prior to entering the program. These events enable female students to connect to a community in the program, encourage belonging, and help them stay in the program.

Current Momentum in the Field

In recent years, there has been heightened discussion and action around the issue of retention of female students in engineering and computing programs, with a greater focus on institutional changes -- in addition to support programs -- and evaluation.

Borne out of the success of the Harvey Mudd computer science program is the current BRAID[77] Initiative (2014) and the initiative's research component BRAID Research, currently based at UCLA. The initiative, led by Harvey Mudd College and the Anita Borg Institute, is a commitment made by fifteen computer science departments across the county to adopt practices modeled after the Harvey Mudd to increase the numbers of women and underrepresented

[77] Building, Recruiting And Inclusion for Diversity

minorities in their programs.[78] Efforts are focused on practices such as modifying introductory computer science courses, increasing outreach and creating interdisciplinary majors to accommodate diverse interests. The Donald Bren School of Information and Computer Sciences at UC Irvine is part of the nationwide initiative. BRAID receives funding from companies including Google, Microsoft, Intel, CRA and the National Science Foundation. BRAID Research, under the direction of UCLA professor Dr. Linda Sax, is currently conducting a mixed-methods longitudinal study tracking the implementation and effectiveness of policy changes at the designated BRAID campuses.

The public is also taking note. In January 2017, a special report from the Chronicle of Higher Education, a publication on news and trends in higher education, published "Keeping Women in STEM" and featured the debate over retention strategies and campus efforts to retain female students in engineering and computer science programs. Featured efforts include female faculty hiring efforts at the University of Toronto, female-only computer labs at the University of Illinois Chicago, and a greater focus on the elimination of bias in the engineering classroom.[79]

Current action suggests that in addition to increased discussion and evaluation of retention strategies at college campuses across the country, there is also increased buy-in from administrators for re-evaluating current practices and supporting institutional changes to increase retention. Further, the need to look *within* the program structure for change is increasingly critical as female engineering retention in the professional sphere has continued to receive more attention and outcry.

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[78] "A Study of Gender and Racial/Ethnic Diversity in Computer Science," *BRAID RESEARCH* Accessed February. 21, 2017. https://braidresearch.gseis.ucla.edu.
[79] Anft, Michael. "A Lab of Her Own." *Chronicle of Higher Education*. January 22, 2017. http://www.chronicle.com/article/A-Lab-of-Her-Own/238970?cid=cp86.

POLICY ALTERNATIVES

I. Methodology

In formulating policy alternatives, we identified on-going programs and best practices that addressed retention barriers identified in our findings and were likely to increase the retention rate of female engineering students. We then developed a preliminary list of alternatives, many of which are adaptations of existing practices, as well as new alternatives based on findings from the literature and interviews. Five alternatives were selected for further evaluation.

Table 8: Overview of Policy Alternatives Addressing Identified Barriers for Female Engineering Students

Policy Alternatives					
Identified Barriers	**Diversity Task Force**	**Diversity Awareness in Curriculum**	**Research Opportunities**	**Peer-to Peer Mentorship**	**Themed Housing for Female Engineers**
Lower levels of self-confidence		×	×	×	×
Lack of “engineering” identity	×	×	×	×	×
Loss of interest in the field			×		
Lack of faculty engagement	×	×	×		

II. Criteria Evaluation

We assessed the anticipated outcomes of our policy alternatives using the following criteria:

1. Anticipated Effectiveness;
2. Cost Feasibility; and
3. Institutional Feasibility

Measurement for each criterion was based on a normative assessment of the anticipated policy outcome. Each policy was ranked high/medium/low on each criterion.

1. Anticipated Effectiveness

Our measure of anticipated effectiveness is based on the expected ability for the alternative to yield an outcome that addresses the policy problem and meets our policy objectives. Our interest is in whether the alternatives produce an increase in the retention rate of undergraduate female students in engineering programs. Subsequently, effectiveness is measured by the degree of expected success, if any, of the alternative.

In assessing effectiveness, we found limited research on policies specifically related to engineering retention and utilized reports on existing initiatives that produced comparable results. Some policies and programs we assessed targeted retention year-to-year rather than graduation rates, or different demographic groups for retention improvement (i.e. STEM vs. engineering). Therefore, our research also includes assessments of policies that address policy problems analogous to our own.[80]

[80] Bardach, Eugene. *A Practical Guide for Policy Analysis: The Eightfold Path to More Effective Problem Solving.* (CQ Press College (4th Edition), 2012), 15

2. Cost Feasibility

Each policy alternative was also assessed on the expected cost of implementation (e.g. up-front, operational, direct/indirect). Given the University of California's strict budget constraints, the feasibility of an alternative is highly dependent on the cost incurred per campus. We encountered challenges in determining the expected cost of policy alternatives due to a lack of available information on the costs of "best practice" policies and programs prominent in the literature; the difficulty in isolating policy costs from general retention/STEM-specific expenditures; and the complexity of UC, campus and departmental budgets. In most cases, feasibility was determined through a normative assessment of expected costs.

3. Institutional Feasibility

Each policy option was evaluated on the level of support anticipated from stakeholders at the University of California. We assessed whether the policy option could garner support for approval and implementation from administrative officials, faculty, and students in the UC system. We believe this criterion to be as important as the other criterion listed because regardless of how effective a policy outcome is anticipated to be, there would be little to no likelihood of implementation if the policy meets strong opposition or has little support from the UC community.[81] Evidence for feasibility came from interviews as well as literature on retention and best practices.

[81] Bardach, Eugene. *A Practical Guide for Policy Analysis: The Eightfold Path to More Effective Problem Solving.* (CQ Press College (4th Edition), 2012), 41

Policy Alternative 1
Diversity Task Forces for Engineering Schools

Background:

In recent years, there has been a substantial push across schools and UC campuses to further explore diversity, equity and inclusion on campuses. In spring 2015, UCLA faculty approved the College of Letters and Science Diversity Requirement at UCLA, which at the time was only one of two UC campuses without a diversity requirement for its primary schools. The same year saw the establishment of the Office of Equity, Diversity and Inclusion here at UCLA led by Vice Chancellor Jerry Kang.

Shortly after the passage of the College of Letters and Science requirement, the engineering school at UCLA, which does not have a diversity requirement, convened a Diversity Committee dedicated to assessing the diversity climate of the school, and identifying ways in which the campus can integrate diversity into their current curriculum.[82] Through surveys, the committee collected student data and recommendations that offered detailed suggestions on how the campus could better serve the needs of the student body.[83]

Currently, other engineering programs with committees dedicated to diversity and equity include: the College of Engineering Equity and Diversity Committee at the University of Wisconsin-Madison and the Broadening Participation Committee in the engineering program at UC Berkeley.

Policy Alternative:

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[82] Weltman, Gershon. Interview by Traci Kawaguchi and Eri Suzuki. UCLA, February 8, 2017.
[83] Weltman Gershon, HSSEAS Committee on Diversity. *Engineering Students' Ideas about Diversity at the UCLA Henry Samueli School of Engineering and Applied Science*

Diversity tasks forces would provide the administration with an apparatus for assessing the diversity climate, reviewing current practices with respect to equity and inclusion, and recommending action. Committees should be comprised of representatives from the administration, faculty and students to ensure representation from all campus stakeholders. Committees can be established for the explicit purpose of engineering program assessment, with continuation of committee work contingent on progress and support.

Though the effectiveness of the committee work at UCLA is not yet known, we feel that a strategy of “learning more” can offer insight into how students view the climate in the program and offer important, student-driven guidance on actions schools can take. Further, a program-wide assessment can reduce the risk and the costs of implementing programs that may not meet the needs of the student body.[84]

One method of data collection is through the administration of program-wide surveys, which can give engineering schools information directly on how students perceive diversity on campus and create a feedback channel for recommendations on changes and enhancements that meet the *actual*, rather than perceived, needs of the student body. While there are currently UC and campus-wide undergraduate surveys intended for similar purposes (i.e the University of California Undergraduate Experience Survey), a survey tailored to the program will likely be more beneficial and efficient for identifying program-specific needs. Further, efforts that focus on the engineering student population as a whole - rather than just engagement with student organizations or voluntary surveys - will offer engineering programs a more accurate representation of their student body, by including students who may be less involved in student groups and lack an avenue for student input. Having the work of the committee public is also

[84] Bardach, Eugene. *A Practical Guide for Policy Analysis: The Eightfold Path to More Effective Problem Solving*. (CQ Press College (4th Edition), 2012), 18

key. We strongly feel student awareness of committee work can send a signal that the program is taking active steps toward addressing the needs of underrepresented students through systemwide change.

Diversity Task Forces for Engineering Schools
Criteria Evaluation

Anticipated Effectiveness- Low

The effectiveness of a committee depends on factors such as committee structure, intended outcomes and accountability. For the purposes of this analysis, we rate the creation of diversity committee as **low** in meeting our measure of effectiveness (i.e. raising retention rates). First, effectiveness is contingent on the feasibility of recommendations and whether the administration implements recommendations. Further, if implemented, the effect of committee action on retention is not only difficult to measure, but would be based on potential behavior change and response and therefore a second-order effect. Given the longer time-horizon (e.g. committee recommendations, actions, and effects - if any - on students) required, the effect of committee work on retention rates may be seen until later.

Cost Feasibility- Medium

We recognize that costs for committee development are dependent on the objective of the committee, and the financial resources required to meet directives. Conducting formal campus assessments and evaluations will require funding from the administration. In the case of UCLA, the survey was conducted as part of a course, thereby cutting administrative costs. Given the variability, we assess cost feasibility as **medium**.

Institutional Feasibility-High

Institutional support for a committee will depend on whether engineering programs see diversity as an immediate issue, and whether there is momentum to take action. In the case of UCLA, institutional feasibility was higher due to campus-wide discussions of the College of Letters and Science Diversity requirements and the recent creation of the Office of Diversity, Equity and Inclusion. Based on a survey of UC engineering program strategic plans and stated goals on websites, programs continue to voice a commitment to greater diversity and equity. Therefore, we feel the creation of a committee would have institutional support from school officials, faculty and students.[85][86] We consider the option **high** in institutional feasibility.

[85] Seible, Frieder et al. "Charting the Course IV - 2007-2010 and Beyond," *Jacobs School of Engineering, University of California, San Diego.* Accessed March 18, 2017 http://jacobsschool.ucsd.edu/about/docs/CtCIVvision.pdf

[86] Apelian, Diran, "UCI Excellence - Ideas, Ideals, and Impact: The Samueli School Strategy Plan," *Samueli School of Engineering, University of California, Irvine.* Accessed March 18, 2017 http://engineering.uci.edu/files/v28-final-ssoe-str-plan.pdf

Policy Alternative 2:
Diversity Education in Engineering Coursework

Background:

In the 2015 report "Solving the Equation", the American Association of University Women outlines steps engineering faculty can take toward the consideration of diversity in the classroom, such as the use of gender-neutral examples and a greater emphasis on range of skills required for success in the field, to foster a sense of belonging in the field.[87] In addition to more inclusive teachings, *bringing attention* to diversity itself may be pathway through which engineering programs can foster a learning environment hospitable to all students.

Doing so, one can argue, can lead to an improvement in the climate for underrepresented groups in engineering programs and encouraging persistence in the program. Currently, at UCLA, there are three "schools" [88] which have an undergraduate diversity course requirement for graduation: the aforementioned College of Letters and Science (for freshman entering in 2015), the Herb Alpert School of Music (for freshman entering in 2016), and the School of Arts and Architecture (pre-2015). However, given the constraints of the core curriculum in engineering, adding a diversity course requirement has been expressed as difficult for the engineering school.

In response to the interests from students, particularly from women, for diversity-related coursework expressed in the Committee survey, lecturer and Diversity committee co-chair Dr. Gershon Weltman incorporated diversity teachings into his lectures on Effective Teams and

[87] "Solving the Equation: The Variables for Women's Success in Engineering and Computing", *American Association of University Women*, 2015. Accessed Jan 15, 2017

[88] For the purposes of this paper, college and school refer to the Henry Samueli School of Engineering and Applied Science. The term "campus" is used to refer to UCLA, while "department" refers to the specific program within the Engineering school (e.g. Electrical Engineering, Bioengineering).

Leadership for his course on Engineering and Society. The course is one of two which fulfill an undergraduate ethics requirement for the engineering college. In addition to highlighting the positive impact of gender diversity on team performance through case studies, the module addresses aspects of diversity including: 1) departmental efforts to address diversity on campus; 2) real-time student assessments of the diversity climate; and 3) implicit biases and micro-aggressions.

Other engineering programs across the country have introduced elective coursework that focused on diversity in engineering. One example is Purdue University, where the engineering program has introduced two seminars focused on gender issues: Women in Engineering (one-unit course for freshmen women), and Gender in the Workplace (for junior and senior students).

Policy Alternative:

This option would encourage engineering programs to adapt required coursework to include case studies and teachings related to diversity awareness, in a model similar to the aforementioned example of Engineering and Society. *This is a recommendation in line with that of the Diversity Committee at the UCLA Engineering school.* Schools can take steps to identify courses that fall under program requirements (i.e. the Ethics requirement at UCLA), where diversity awareness can be incorporated in a compatible manner.

While adding elective coursework on gender and diversity in engineering may yield benefits to female and minority, we recognize the rigor of the program course load for all students, and strongly believe that the incorporation of diversity literature in courses intended for all engineering students may lead to a more supportive campus requirement and less of a burden for underrepresented students.

Diversity Education in Engineering Coursework
Criteria Evaluation

Anticipated Effectiveness - Low

The impact of "diversity awareness" on retention is likely to be **low**, given the option's *indirect* approach to raising retention rates. While it may be successful in meeting addressed needs and elevating awareness of unconscious biases and the value of diversity in the profession, effectiveness will depend on practice by faculty members, and responsiveness and behavioral changes by students in the program.

Cost Feasibility - High

The cost of implementing a content-based change will depend on the form in which the curriculum change occurs. The addition of a diversity requirement, for example, would incur heavy costs on the administration, faculty and students given program constraints that limit flexibility in the program. The alternative we propose is adapting current coursework to include diversity awareness, as with Engineering 183EW (Engineering and Society). Cost calculations, then, are based on *course modifications* rather than the costs of adding new courses or the adoption of a new requirement. We consider dollar costs to be low and cost feasibility is likely to be **high**.

Institutional Feasibility - Medium

The mission and creation of the Diversity Committee, in itself, signals support for diversity-based initiatives within the administration of the engineering school. However, implementation is contingent on support from faculty members who teach courses that best lend themselves to modifications. In the case of UCLA, feasibility for content changes was high due to the instructor's own involvement in the work of the committee and recognition of the value of teaching diversity awareness. This may not be the case across all campuses and therefore we evaluate this as **medium** in institutional feasibility.

Policy Alternative 3:
Additional Research Opportunities for Female Students in STEM

Background

Based on our findings, we believe that providing opportunities for hands-on research and greater faculty engagement will increase the likelihood of female students staying in the engineering. Undergraduate research opportunities are proven to improve student interests in the field, retain them in major, and prepare them for advanced education and careers in research. Such programs exist on each UC campus.[89][90][91] However, we have not found programs that focus specifically on female undergraduate engineers. Since studies show that the rate of female students participating in STEM research opportunities are lower than that of male students, having female-focused research opportunity programs will give female students a strong incentive to participate the programs and may result in the greater student retention.[92]

We find that some universities administer undergraduate research programs specifically for female students in STEM, including engineering. For example, the University of Cincinnati's Women in Science and Engineering (WISE) program[93] provides female undergraduate students with research experience through the Research Experience for Women Undergraduate (REWU) Program.[94] The 12-week summer program gives female engineering students an opportunity to

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89 "Undergraduate Research." *UCLA.* Accessed March 4, 2017. http://www.ucla.edu/research/undergraduate-research.
90 "Undergraduate Research Center." *UC Davis.*Accessed March 4, 2017. https://urc.ucdavis.edu/.
91 "Office of Undergraduate Research and Scholarship." *UC Berkeley.* Accessed March 4, 2017. http://research.berkeley.edu/.
92 Berkes, Elizabeth. "Undergraduate Research Participation at the University of California, Berkeley." *Research & Occasional Paper Series: CSHE.* 17.08. (2008): 6, 12
93 "Women in Science and Engineering (WISE)." *The University of Cincinnati, Women in Science and Engineering (WISE).* Accessed March 2, 2017. https://www.wise.uc.edu/wise/index.php
94 "REWU Program." *The University of Cincinnati, Women in Science and Engineering (WISE).*Accessed March 2, 2017. https://www.wise.uc.edu/wise/rewu.php.

work closely with faculty on research projects proposed by faculty members from all STEM fields.[95] REWU also includes a mentoring component, which provides program participants an opportunity to meet weekly with assigned faculty to discuss project progress and participate in a professional research conference at the conclusion of the program.[96]

Locally, the University of Southern California (USC) offers a two-tiered Women in Science and Engineering (WiSE) Undergraduate Research Experience program: WiSE Fellows and WiSE Researchers.[97] WiSE Fellows targets students in the early stage of research with opportunities to conduct research in an academic setting and develop a mentoring relationship with faculty advisors.[98] WiSE Researchers supports research projects of selected upperclassmen with existing working relationships with faculty members. The program is intended to help students gain a higher likelihood of entry into graduate studies.[99]

Policy Alternative

This option would provide female students with added research opportunities that offer hands-on application and opportunities to establish working relationships with faculty. Since attrition of female students in engineering is more likely to happen during their freshman and sophomore years, programs should focus on students in their first two years of the program. Research opportunities can also facilitate the development of a mentoring relationship between

[95] "REWU Program." *The University of Cincinnati.* Accessed March 20, 2017. https://www.wise.uc.edu/wise/rewu/rewu.php3
[96] "The Women in Science and Engineering (WISE) Program at the University of Cincinnati." *The University of Cincinnati, Women in Science and Engineering (WISE).* Accessed March 2, 2017. https://www.wise.uc.edu/projectDocs/2017/WISE_2017_ProgramAnnouncement_Updated_Jan13.pdf.
[97] "WiSE Undergraduate Research Experience." *The University of Southern California, Women in Science and Engineering (WiSE).* Accessed March 2, 2017. https://wise.usc.edu/our-programs/grants-and-awards/undergraduate-students/wise-undergraduate-research-experience/.
[98] Ibid.
[99] Ibid.

female students and faculty, which has shown to be important to support student self-efficacy. We would encourage engineering schools to introduce Women in Science and Engineering-type research programs through collaborations with other on-campus STEM programs, undergraduate research opportunity initiatives and offices focused on gender equity. This may be valuable for support given the narrow scope of the program. Additionally, collaborations with existing programs would be efficient because they can utilize resources and know-how to administer the program. Therefore, the programs are best run in tandem with multiple schools, departments, and units on campus. In order to do so, we suggest that programs fall under the guidance of campus-wide administrative offices, rather than individual schools.

Following the model of similar summer research programs, we suggest that research projects take place during summer break since both faculty and students are more likely to participate in the projects.

Additional Research Opportunities for Female Students in STEM
Criteria Evaluation

Anticipated Effectiveness - High

Several studies show that research opportunities have a positive impact on retention.[100][101][102][103] The chair of the University of Cincinnati's WISE REWU program notes on

[100] Nagda, Biren A. et al. "Undergraduate Student-Faculty Research Partnerships Affect Student Retention." *The Review of Higher Education* 22.1. (1998). Accessed February 12, 2017

[101] Vieyra, Michelle., Gilmore, Joanna. and Timmerman, Briana., "Requiring Research May Improve Retention in STEM Fields for Underrepresented Women." *Council on Undergraduate Research Quarterly.* 32.1. (2011)

[102] Peckham, Joan. et al. "Increasing Student Retention in Computer Science through Research Programs for Undergraduates." *SIGCSE '07 Proceedings of the 38th SIGCSE Technical Symposium on Computer Science Education.* (2007). Accessed February 12, 2017. doi: 10.1145/1227310.1227354

[103] Alvarado, Cristine., Dodds, Zachary., and Libeskind-Hadas, Ran. "Increasing Women's Participation in Computing at
Harvey Mudd College" *Magazine ACM Inroads.* 3.4. (2012) Accessed February 14, 2017.
doi: 10.1145/2381083.2381100

the program website that research participation has had a positive impact on the student retention rate, and has strengthened participant educational experiences overall.[104] Programs can also create a new network with faculty and people working at the lab.[105] SRC Undergraduate Research Opportunities (URO)[106]reports that over 95% of students participating in the program continue pursuing science and engineering field.[107]

Studies and interviews show that research opportunities are more likely to have a stronger impact on retaining female students in engineering fields by improving female students' confidence and tapping into interests, which are important aspects that influence female students' decisions to stay in the field. Thus, we rank this policy alternative as **high** for anticipated effectiveness.

Cost Feasibility - Low

This policy alternative is evaluated as **low** for cost feasibility because of the high administrative and operational costs of launching a new program. First an office or a department will need to hire coordinators to administer this new program. Costs, however, could be decreased by collaborating other departments, divisions, and/or units such as division of undergraduate education, undergraduate research centers, and/or campus diversity offices by using resources and know-how existing in those offices.

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[104] Duvelius, Ashley., "WISE REWU Program Seeks Faculty Mentors" *The University of Cincinnati News*. Accessed March 2, 2017. http://www.uc.edu/news/NR.aspx?id=24612.
[105] Ibid.
[106] Semiconductor Research Corporation (SRC) Undergraduate Research Opportunities (URO) sponsored by SRC's Education Alliance and Intel provides undergraduates with valuable research experience and mentoring. "Undergraduate Research Opportunities." Semiconductor Research Corporation. Accessed March 2, 2017. https://www.src.org/program/srcea/uro/.
[107] Ibid.

Further, undergraduate research opportunities often provide each student a stipend in the range of roughly $500 to $4500.[108][109][110] Therefore, as more female students are accepted in the program, the cost feasibility decreases due to increased costs.

To provide a cost example, the University of California's Leadership Excellence through Advanced Degrees (UC LEADS)[111] offers educationally and economically disadvantaged undergraduate students with research experience and graduate school preparation. The state of California annually grants annually ten UC campuses $458,000 in funding as part of the Student Academic Preparation and Education Partnership (SAPEP).[112] Even though a WISE research program might not be as costly as UC LEADS given the smaller number of participants and the use of existing resources, launching a new WISE research program could be still a burden on the UC schools. Thus, if the UC schools considered the adoption of a WISE research program in the same format as UC LEADS, this would cost roughly additional $500,000 to the system per year.

Institutional Feasibility - Low

We assess this policy alternative as **low** for institutional feasibility. It would be difficult to gain support of the policy option from the UC campuses due to the high costs of operation.

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108 "WiSE Undergraduate Research Experience." *The University of Southern California, Women in Science and Engineering (WiSE)*. Accessed March 2, 2017. https://wise.usc.edu/our-programs/grants-and-awards/undergraduate-students/wise-undergraduate-research-experience/.

109 "Historical Report 2000-2015: Preparing Promising Scholars for Graduate Education in Science, Technology, Engineering, and Mathematics (STEM) Since 2000." *University of California Leadership Excellence through Advanced Degrees Program (UC LEADS)*: 6 Accessed March 2, 2017. http://ucleads.org/images/UC%20LEADS%20Historical%20Report%202015%20FINAL.pdf

110 Duvelius, Ashley. "WISE REWU Program Seeks Faculty Mentors." *The University of Cincinnati News.* February. 7, 2017. Accessed March 2, 2017. http://www.uc.edu/news/NR.aspx?id=24612.

111 "UC LEADS." *University of California, Office of the President, Graduate Studies.* Accessed March 2, 2017. http://www.ucop.edu/graduate-studies/initiatives-outreach/uc-leads.html.

112 "Historical Report 2000-2015: Preparing Promising Scholars for Graduate Education in Science, Technology, Engineering, and Mathematics (STEM) Since 2000." *University of California Leadership Excellence through Advanced Degrees Program (UC LEADS)*: 8. Accessed March 2, 2017. http://ucleads.org/images/UC%20LEADS%20Historical%20Report%202015%20FINAL.pdf.

Additionally, UC campuses may not prioritize this alternative given existing undergraduate research programs, though not gender specific. Ultimately, institutional feasibility for this alternative is likely to be **low**.

Furthermore, using existing initiatives and collaborating with other schools can be a double-edged sword because existing programs may be reluctant to use limited resources on a new program. Expecting collaboration across offices also means that each office or department will need to coordinate positions of supporting new and existing programs. Cross-departmental coordination will be time-consuming and may deter offices and departments from supporting the policy alternative.

Lastly, it may be difficult to get support from faculty. Implementing a new research opportunity program requires buy-in from faculty willing to participate as well as invest their time in developing a mentor relationship with program participants. Given the numerous undergraduate research opportunities available in the UCs, asking faculty for more assistance and to work with students without research experience could place additional burdens on faculty.

Policy Alternative 4:
Peer Mentoring Programs for Freshmen Female Students

Background:

Peer mentoring programs are a common strategy for campuses to promote college success. Based on the literature and student interviews, we find that this holds true for female students in engineering.

Through peer mentoring programs, upperclassmen can help incoming students acclimate to the engineering environment quickly, answer questions related to studying and life on campus, and help them prepare early in the program. For women, in particular, mentoring programs offer incoming students first-hand perspective on being a female engineering student, which can help establish self-confidence in their abilities to succeed in the program and promote a sense of belonging through connection. Further, by providing direct support, the program can help students overcome difficulties early in the program where the potential for leaving is highest.

Programs for female students may be particularly important in the sciences. Mentoring programs in male-dominated fields (i.e. sciences, technology) are found to be conducted in ways that meet male socialization patterns, with a priority for instrumental and technical guidance[113]. This may include a greater emphasis on challenging mentees and promoting independence, which may not meet the social needs and preferences of female students in the program.[114] Research also finds that a mentee who has a mentor of a different gender had a lower level of comfort.[115] Given the high percentage of men in STEM fields, it follows that female mentees are

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[113] Seymour, Elaine. and Hewitt, Nancy M. *Talking About Leaving: Why Undergraduates Leave the Science* (Westview Press, 1997), 261

[114] Misra, Joya et al. "Collaboration and Gender Equity Among Academic Scientists." *Social Science* (2017), 6(1), 25. Accessed March 20, 2017, doi:10.3390/socsci6010025

[115] Worell, ed., *Encyclopedia of Women and Gender, Two-Volume Set: Sex Similarities and Differences and the Impact of Society on Gender* (Academic Press, 2001), 746-747

more likely to have male mentors in a schoolwide program. [116][117] Therefore, programs for female students are better suited for supporting women, particularly in male-dominated fields like engineering.

Peer mentoring programs for STEM females have been successful in decreasing attrition rates. The University of Iowa self-reports that the Women in Science and Engineering peer mentoring for STEM female students resulted in a 71% retention rate among program participants, a figure higher than the national rate of 30 - 46% in 2003.[118] More than half of mentees continued on to become mentors, indicating personal benefits from participation in the program for both mentees and mentors.

Engineering schools themselves have also adopted peer mentoring programs targeted at incoming female engineering students. Programs include the Mentor and Mentees program at Georgia Tech's (College of Engineering), the Women in Engineering mentoring program at the University of Kentucky, and WISE Peer Mentoring program at the University of Michigan.

Peer mentoring program can come in various forms. At UCLA, for example, the engineering school launched the peer mentoring program MentorSEAS, which is open to all incoming engineering students. Other programs are run through student groups including the Society of Women Engineers at UCLA. The popularity of programs indicates high student support for the program. Through affinity groups are a common organizer of peer mentoring opportunities, we also find female-specific programs administered formally on other campuses,

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[116] "Centering on Mentoring: A Training Program For Mentors And Mentees", American Psychological Association. Accessed March 5, 2017. https://www.apa.org/education/grad/mentoring-training.pdf

[117] "Mentor/Mentee Initiative." *INCOSE*. Accessed March 19, 2017. http://www.incose.org/ChaptersGroups/initiatives/ewlse/mentorship.

[118] "Peer Mentoring." *The University of Iowa, Women in Science and Engineering.* Accessed March. 05, 2017. https://uiowa.edu/wise/peer-mentoring

including the “Big/Little Sister Mentoring Program” run by the Electrical Engineering and Computer Science department at UC Berkeley.

Policy Alternative:

One alternative to increase retention is the incorporation of female peer-mentoring programs into strategies for retaining female students in engineering. Based on best practices, programs should match incoming female students with female students who have been in the program for at year one to two years, preferably in the same department. Though peer mentoring programs exist among student groups, formal programs administered by schools are found to be more effective in meeting student needs.[119]

Peer Mentoring Programs for Freshmen Female Students
Criteria Evaluation

Anticipated Effectiveness - Medium

Numerous studies find that peer mentoring programs increase retention rates for students. We find that to be true for programs for female engineers, by directly addressing some of aforementioned barriers to persistence including a lack of self-confidence and the drop in field interest. A formal survey at the University of Toledo finds that of among various retention efforts targeted at female engineers, peer mentoring was rated the highest in helpfulness among female students. Further, the higher-than-average female student retention rates published by school programs indicates effectiveness as well.

[119] Inzer Lonnie D., Crawford C.B. “A Review of Formal and Informal Mentoring: Processes, Problems, and Design,” *Journal of Leadership Education* 4.1.(2005): 31-108 Accessed March. 15, 2017 http://aole.memberlodge.org/Resources/Documents/jole/2005_summer/JOLE_4_1.pdf#page=35

The effectiveness of a given peer mentoring program is highly contingent on program administration and the quality of the mentoring relationships developed through the program. For students who have a negative or sporadic connection with their mentors, participation in the program may have no effect or, at an extreme, a negative effect on persistence. Further, success of the program will also rely on the supply of upperclassmen willing to participate in the program. We anticipate the effectiveness of a peer mentoring program as **medium.**

Cost Feasibility - Medium

We recognize that there are substantial operating costs in administering a successful student program. Operational costs include the hiring and compensation of program staff, program marketing, mentor training and the sponsorship of regular social events to ensure connections between mentors and mentees. Further, incentives for senior students to apply and effectively participate may be required, particularly if the supply of potential mentors is low and/or if similar mentoring programs exist in competition. Costs are also determined by the size of the program. Based on the factors above, we score this as **medium** for cost feasibility.

Institutional Feasibility - Medium

However, we feel that this policy alternative may be difficult to gain traction from engineering programs themselves. First, given the other mentoring opportunities available on campus, it is difficult to measure the impact of the program. Moreover, in the program may not have an effect in the short term, which may make it difficult to justify the costs and labor required to establish a consistent mentoring program. Evidence suggests, however, that students are likely to be in support of peer mentor programs both as mentors and mentees. Therefore we assess institutional feasibility as **medium.**

Policy Alternative 5:
Learning Living Communities for Female Engineering Students

Background:

Interviews with female students suggest that peer support from other female engineering students is critical for success in the program. In addition to affinity group participation (i.e. SWE, WATT), having close female friends in the program and/or classmates as roommates are ways female students interviewed have found peer support socially and academically.

Further, research shows that developing an identity based on the student's field of interest (i.e. self-identification as "an engineer") is strong factor in a student's decision to select a particular major.[120] Therefore, cultivating a sense of engineering identity early in the program may be a key to success.

To foster a sense of belonging and support, universities across the country have increasingly adopted residence halls or learning communities targeted at incoming female engineering students. The residences seek to help female freshman transition to college through an immediate network of social and academic support, both of which, students said, were important for persistence. In addition, these communities often have organized social activities, peer mentoring programs, and academic resources including tutoring services. Themed residences are particularly common at large public universities.[121] Examples include Hyapatia at Virginia Tech, the Douglass Engineering Living Community at Rutgers University, and the Women in Engineering Living Learning Community at the University of Texas at Austin.

Policy Alternative:

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[120] Lehman, Kate. Interview by Traci Kawaguchi and Eri Suzuki. UCLA, February 15, 2017.
[121] Anft, Michael. "Female-Only 'Nerd' Dorm Help Keep Women in Engineering," *The Chronicle of Higher Education*. January 22, 2017. Accessed March 04, 2017 http://www.chronicle.com/article/Female-Only-Nerd-Dorm/238963

Establishing living communities for female engineering students is one way campuses can facilitate connections within the female student population. We recognize that science and engineering-centered residential communities exist at almost all UC campuses, including learning living communities for female STEM students (i.e. UC Berkeley WISE, UC Santa Barbara Women in Science and Engineering). Yet, we feel that communities specifically for female engineering and computer science students can offer added support to help students overcome challenges unique to the program, namely the low numbers.

While the establishment of engineering-only and female in STEM communities may foster the same feeling of support, providing female engineering students with additional avenues for direct contact and networking with one another can lessen implicit advantages that male students may have in the program. This strategy of eliminating "pro-male bias" implicit in male-dominated programs, through additional support for women is one that is currently effective at Carnegie Mellon University.[122]

Further, having a formal system could make it easier for interested students to connect. One computer science student interviewed said that while hesitant at first, having two female roommates from the same program allowed her to have friends quickly in the program. In this case, the student found potential roommates through Facebook.

Learning Living Communities for Female Engineering Students
Criteria Evaluation

[122]Anft, Michael. "Female-Only 'Nerd' Dorm Help Keep Women in Engineering," *The Chronicle of Higher Education*.
January 22, 2017. Accessed March 04, 2017
http://www.chronicle.com/article/Female-Only-Nerd-Dorm/238963

Anticipated Effectiveness - High

We feel that participation in female engineering living communities can be effective in encouraging women to stay in the program through the early cultivation of support networks. Social networks can encourage a sense of belonging and reduce the sense of isolation felt by students, especially at a large public university. Similar programs have found to be successful. The Chronicle of Higher Education reports that Hyapatia (Virginia Tech) participants have an 80% rate of staying in the engineering program compared to the average of 69% for all engineering students.[123] Therefore, we anticipate a **high** level of effectiveness for this alternative in meeting our objectives of increasing retention rates. We recognize, however, that the benefits will come to students who participate in the program and in cases where there is limited supply of housing, students who apply and are accepted into the program. Further, students who apply for the program may be more inclined to build social networks and may not be representative of all female students in the program.

Cost Feasibility - Medium

As campuses consider increasing the housing supply for its student body to accommodate increases in enrollment, we see a particularly open window of opportunity for the inclusion of additional residential communities. Infrastructure and general administration costs of establishing a living community would be incorporated into proposed housing plans. Added costs will come from administrative and programmatic expenses related to specific implementation and organization of each community including the hiring and compensation of

[123] Anft, Michael. "Female-Only 'Nerd' Dorm Help Keep Women in Engineering," *The Chronicle of Higher Education*.
January 22, 2017. Accessed March 04, 2017
http://www.chronicle.com/article/Female-Only-Nerd-Dorm/238963

staff, funding for social events and community programs. Common programs in these residential communities include program-specific peer mentoring, tutoring services, seminars and often a coursework component to the program. Therefore, we find this to be **medium** in cost feasibility.

Institutional Feasibility - Medium

Themed residential housing programs are often co-facilitated by campus housing services and the related college/program. In the case of housing for female engineers, the living communities are often ran in tandem with Women in Engineering offices located at engineering schools (e.g. The Ohio State University, the University of Texas Austin). We anticipate support from programs given their proven effectiveness and the window of opportunity with proposals for increased undergraduate housing. Feasibility, however, may rely on the presence and resources of similar Women in Engineering-type offices, which we did not find at any UC campuses. Further, given the presence of similar STEM residential programs for women and the relatively small number of students this program would target, it may be a lower priority for campuses. Therefore, we rate institutional feasibility as **medium**.

Table 9: Decision Matrix

Policy Alternatives	Evaluative Criteria			Total Score
	Anticipated Effectiveness	Cost Feasibility	Institutional Feasibility	
Diversity Task Force	Low	Medium	High	**6**
Diversity Awareness in Curriculum	Low	High	Medium	**6**
Research Opportunities	High	Low	Low	**5**
Peer-to Peer Mentorship	Medium	Medium	Medium	**6**
Themed Housing for Female Engineers	High	Medium	Medium	**7**

Score
High: 3 points
Medium: 2 points
Low: 1 point

RECOMMENDATIONS

Improving female retention in engineering requires identifying programs and policies that improve self-confidence, tap into student interests, promote a sense of belonging, and change the environment and climate in engineering schools to be more welcoming of women. Based on best practices and interviews, we developed five policy alternatives that can address identified barriers and recommend the following:

1. We recommend that the UC engineering schools first consider launching programs that provide added resources for female undergraduate students. Among the policy alternatives introduced in the previous section, our first recommendation is for engineering schools to work in conjunction with campus administration to provide a residential community for female engineering students. Not only did this alternative score the highest in our assessments, we believe that there is a policy window to take action given proposed increases in housing.

   Secondly, we believe other programs such as peer mentorship and research opportunities, can increase self-confidence and belonging through support networks from peers and faculty members, and opportunities to apply theory to practice. Offering additional opportunities for women to connect can also offset some of the natural advantages men have in the program by virtue of numbers. The challenge for these alternatives, however, may be implementation.

2. Furthermore, engineering programs should continue to strive for a learning environment that is conducive to women. No matter how many programs a school implements, they will not reach their full effectiveness unless schools institutionalize diversity and address the subtle disadvantages women have being largely outnumbered by men. We strongly encourage that UC engineering schools create a temporary diversity task force that surveys and reports on student perceptions of the diversity climate and recommendations for school action. We believe there is great value in a committee that focuses on underrepresented student groups, not solely women, given the intersections and common challenges underrepresented students face. Committees and task forces can be a forum where administrators, faculty and students can openly discuss the issue of gender diversity, grasp the current situation, and create a strategic plan to address the issue.

   We also encourage the incorporation of diversity awareness into the curriculum. Active efforts to incorporate diversity principles into core coursework, when feasible, can send students a clear message that engineering schools are prioritizing the value of diversity in their programs, even absent a diversity requirement required in other schools. If effective, we believe this can also have a positive effect on student interactions as well as professional development.

Further Considerations:

We also recommend further consideration of policies and programs not included in our report including the establishment of **Women in Engineering offices** at UC engineering programs, and additional **investments in recruitment materials** targeted at incoming female engineers. Much of the programmatic support for programs targeting retention are managed by offices dedicated to supporting women in the program. Key to implementation of program-based initiatives may be the development of these offices. Within UC, UCLA is currently in the planning stages of a Women in Engineering office that is planned to focus on outreach, retention and professional development.

Second, we also encourage small-scale changes that can connect prospective, newly-admitted and incoming freshman with resources early in the program, and send a message that UC engineering programs are welcoming environments for female engineers. UC Berkeley, for example, has a website for Prospective Female students in Electrical Engineering and Computer Science (EECS) that includes messages from female faculty and students, as well as links to organizations for female EECS students and information on themed housing for women in STEM. Purdue University's Women in Engineering web page is another great example of how programs can use their websites for prospective female student outreach, early engagement and a repository of resources for women. [124] Engineering programs and departments can institute diversity and women-specific sections onto their web pages that highlight resources for women and the accomplishments of women on campus.

Lastly, we recognize the diversity in needs and resources of each UC campus and the limitations of recommending a uniform plan for all. Through this report, we hope to provide campuses with ideas of best practices and encourage campuses to prioritize alternatives that are in the best interests of their programs.

[124] "Women in Engineering at Purdue/ Design life. Engineer." *Purdue University.* Accessed March 21, 2017. http://www.purdue.edu/designlife/

CONCLUSION

The increases in undergraduate enrollment in the UC system provides further opportunities for greater diversity in the UC student population. Ideally, the rise in numbers, along with valuable on-going K-12 STEM outreach efforts, will help to close the gap in gender equity in some of the programs that face the greatest disparities, including computer science and engineering. Through our project, we find that in addition to facilitating increases in enrollment through recruitment efforts, engineering programs must continue to take steps in promoting a positive learning environment to retain female students. What may be key is creating an environment that encourages a sense of belonging and addresses implicit advantages male students may have being in the majority.

To this, we believe that UCOP and its campuses should make female enrollment and retention in engineering a point of focus on its discussions of equity and diversity and encourage cross-campus discussions of best practices. Current literature in the field of retention points to an increasing number of interventions that have been proven to not only increase retention rates, but also raise the proportion of engineering degrees awarded to women. Within the UC system itself, campuses are employing a number of initiatives, from support centers dedicated to assisting underrepresented engineering students to faculty-driven mentorship programs for women in STEM. UC campuses are also involved in national retention initiatives, like BRAID, backing up a commitment to increasing women in computing through action.

What we find most encouraging are the efforts undertaken by female engineering students themselves. While our report focuses on the support functions they provide for their peers on campus, student-led affinity groups additionally dedicate a substantial amount of time and guidance in reaching out to future female engineers. Taking on a dual role of supporting recruitment and retention -- while navigating the general challenges of engineering programs -- the students are taking initiative to eliminate some of the commonly-cited persistence barriers recognized in the literature. If the UC system and campuses are committed to increasing gender diversity in the sciences, we encourage greater engagement with and heightened awareness of student efforts on the ground.

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APPENDICES

Appendix A. Engineering Bachelor's Degrees Awarded to Women by School (2014-2015)

Rank	University	# of Degrees
1	Georgia Institute of Technology	517
2	Massachusetts Institute of Technology	349
3	University of Michigan	342
4	Purdue University	338
5	Univ. of Illinois, Urbana-Champaign	329
6	Ohio State University	310
7	Pennsylvania State University	302
8	University of Florida	288
9	Texas A&M University	286
10	Cornell University	279
11	Virginia Tech	278
12	University of California, San Diego	275
13	University of California, Berkeley	266
14	Colorado School of Mines	256
15	University of Texas, Austin	253

Source: Yoder, B.L. "Engineering by The Numbers"

Appendix B. Percentage of Engineering Bachelor's Degrees Awarded to Women by School* (2014-2015)

Rank	University	% of Degrees	Rank	University	% of Degrees
1	Olin College of Engineering	48.8%	11	Dartmouth College	35.9%
2	M.I.T	45.7%	12	Tulane University	35.7%
3	Harvey Mudd College	41.6%	13	Columbia University	35.6%
3	Howard University	41.6%	14	Harvard University	35.4%
5	George Washington University	41.5%	15	Bucknell University	34.7%
6	Brown University	41.0%	16	Yale University	34.2%
7	Tuskegee University	38.9%	17	Cornell University	34.0%
8	Princeton University	38.5%	18	Vanderbilt University	33.2%
9	William Marsh Rice University	37.7%	19	University of Puerto Rico, Mayaguez	33.0%
10	Southern Methodist University	36.6%	20	Johns Hopkins University	32.4%

**Minimum of 50 total bachelor's degrees awarded.*
Source: Yoder, B.L. "Engineering by The Numbers"

Appendix C: Demographic Characteristics (Weighted N=2471)

	Female		**Male**		**Total**	
	Obs.	**%**	**Obs.**	**%**	**Obs.**	**%**
Engineering Enrollment	**593**	**24.0**	**1878**	**76.0**	**2471**	**100**
Graduated with an engineering degree	334	56.3	1,216	64.7	1,550	62.8
Did not graduate with an engineering degree	259	43.7	662	35.3	921	37.2
Race						
African-American	14	2.4	26	1.4	40	1.6
Asian	294	49.6	927	49.4	1,221	49.4
Hispanic	114	19.3	324	17.3	438	17.7
Other	14	2.4	55	2.9	69	2.8
White	157	26.3	546	29.0	703	28.5
Highest Parental Education						
No High School	37	6.3	106	5.6	143	5.8
Some High School	35	6.0	93	4.9	128	5.2
High School Graduate	75	12.6	210	11.2	285	11.5
Some College	65	11.0	173	9.2	238	9.6
2 Year College Graduate	33	5.6	87	4.6	120	4.9
4 Year College Graduate	150	25.3	496	26.4	646	26.1
Post-Graduate Study	197	33.2	713	38	910	36.9

Data Source: Office of Institutional Research and Academic Planning, UCOP

Appendix D: Summary Statistics (Weighted N=2471)

	Obs.	Mean	Median	STD	Min	Max
Family Income						
Female	593	106327	92309	79284	3118	350000
Male	1878	115024	101388	82015	50	350000
High School GPA						
Female	593	3.98	4.07	.32	3.00	4.46
Male	1878	3.92	4.00	.34	2.80	4.47
SAT Math						
Female	593	649.64	660	93.69	350	800
Male	1878	677.26	690	85.56	320	800
First Year GPA						
Female	593	2.98	2.97	.52	.98	4.00
Male	1878	2.99	2.98	.53	1.26	4.00

Data Source: Office of Institutional Research and Academic Planning, UCOP

Appendix E. List of Interview Participants

Name of Interviewee	**Title/Organization**
Gershon Weltman	Lecturer, UCLA Electrical Engineering Department
Kate Lehman	Project Manager and Research Analyst, Building, Recruiting, and Inclusion for Diversity (BRAID) Research Team
Kimberly Peterson	Manager, Academic Planning Analysis, Institutional Research and Academic Planning (IRAP), the University of California, Office of the President.
Jayathi Y. Murthy	Dean, UCLA Henry Samueli School of Engineering and Applied Science
Female Undergraduate Student	Senior, UCLA Electrical Engineering Program
Female Undergraduate Student	Senior, UCLA Electrical Engineering Program
Female Undergraduate Student	Sophomore, UCLA Computer Science Program
Female Undergraduate Student	Freshman, UCLA Computer Science Program