New Orleans JAZZED about Engineering Education

Paper ID #16414

Innovation through Propagation: Pathways to Studying Engineering, Retention and Diversifying the Learning Community

Dr. Susan M. Lord, University of San Diego

Susan M. Lord received a B.S. from Cornell University and the M.S. and Ph.D. from Stanford University. She is currently Professor and Chair of Electrical Engineering at the University of San Diego. Her teaching and research interests include electronics, optoelectronics, materials science, first year engineering courses, feminist and liberative pedagogies, engineering student persistence, and student autonomy. Her research has been sponsored by the National Science Foundation (NSF). Dr. Lord is a fellow of the ASEE and IEEE and is active in the engineering education community including serving as General Co-Chair of the 2006 Frontiers in Education (FIE) Conference, on the FIE Steering Committee, and as President of the IEEE Education Society for 2009-2010. She is an Associate Editor of the IEEE Transactions on Education. She and her coauthors were awarded the 2011 Wickenden Award for the best paper in the Journal of Engineering Education and the 2011 Best Paper Award for the IEEE Transactions on Education. In Spring 2012, Dr. Lord spent a sabbatical at Southeast University in Nanjing, China teaching and doing research.

Dr. Denise Rutledge Simmons P.E., Virginia Tech

Denise R. Simmons, Ph.D., is an assistant professor in the Myers-Lawson School of Construction and in the Civil & Environmental Engineering Department, and an affiliate faculty of the Department of Engineering Education at Virginia Polytechnic Institute and State University. She holds a B.S., M.S., and Ph.D. in civil engineering and a graduate certificate in engineering education – all from Clemson University. Until 2012, she was the director of the Savannah River Environmental Sciences Field Station. Dr. Simmons has nearly fourteen years of engineering and project management experience working with public utility companies, a project management consulting company, and a software company. She is a registered professional engineer, project management professional and LEED accredited professional. Her career vision is to become a global leader in research that builds capacity and broadens the participation of students completing construction and engineering degrees and entering the technological workforce by shaping practices and policies in retention, informal learning, pedagogy, professional competency, workforce development and life-long learning. Her research interests are in investigating students' development of leadership skills and other professional competencies and in students' involvement in curricular, co-curricular and extra-curricular activities. Dr. Simmons is a NSF CAREER award recipient for her research entitled, "Investigating Co-Curricular Participation of Students Underrepresented in Engineering" and a recently funded NSF award entitled "Preparing a 21st Century STEM Workforce: Defining & Measuring Leadership in Engineering Education" focused on the construction industry. Dr. Simmons is also a 2016 recipient of the College of Engineering Dean's Award for Outstanding New Assistant Professor and the Black Graduate Student Organization's Lisa Tabor Award for Community Service.

Dr. Larry J. Shuman, University of Pittsburgh

Larry J. Shuman is Senior Associate Dean for Academic Affairs and Distinguished Service Professor of industrial engineering at the Swanson School of Engineering, University of Pittsburgh. His research focuses on improving the engineering education experience with an emphasis on assessment of design and problem solving, and the study of the ethical behavior of engineers and engineering managers. A former Senior Editor of the Journal of Engineering Education, Shuman is the Founding Editor of Advances in Engineering Education. He has published widely in engineering education literature, and is co-author of Engineering Ethics: Balancing Cost, Schedule and Risk - Lessons Learned from the Space Shuttle (Cambridge University Press). He received his Ph.D. from the Johns Hopkins University in Operations Research and a B.S.E.E. from the University of Cincinnati. Dr. Shuman is an ASEE Fellow.

Work in Progress - Innovation through Propagation: Improving and Diversifying Pathways

Introduction

Round 1 of the Delphi study of the critical unsolved problems facing engineering education research, described elsewhere[1], included a question on barriers related to "improving and diversifying the pipeline". Several respondents pointed out that the pipeline metaphor has been challenged in the community for its rigidity and expressed a preference for the "pathways" metaphor, which suggests multiple routes instead of a single route. The pathways metaphor is consistent with the literature.[2,3]

For round 2 of the Delphi study, the prompt was changed to "pipeline and pathways". As a result of the Delphi study, these five primary barriers and needs emerged related to improving and diversifying pathways of engineering students as follows.

A. Study the root causes of why engineering remains a primarily white, male field, identify institutions that have successfully broken the stereotype, and determine how they did it.
B. Identify and study those engineering schools and programs that have made substantial progress in increasing under-represented student populations, and determine their best practices.
C. Initiate and synthesize engineering education research focused on the "neglected" cohorts (e.g., LGBTQA, disabled, low income).
D. Determine why some engineering fields are more attractive to under-represented cohorts than other fields.
E. Examine the culture and faculty attitudes of those engineering areas that are least diversified and those that are highly diversified in order to identify best practices and incentives for changing the culture and climate as a first step of increasing the pipeline.

When we think of pathways for engineering students, we typically think of starting in pre-kindergarten and advancing through primary and secondary schools into post-secondary institutions and then the workplace. This paper focuses on pathway impediments occurring as students progress through post-secondary education, specifically four-year colleges. We acknowledge that the other areas are critically important, but we need to limit the scope here. We believe this scope is appropriate because the primary audience for this paper comprises engineering faculty (practitioners of education), engineering administrators (deans, department chairs), classroom innovators, and engineering education researchers.

The four foci that resulted from these critical problems in the four-year college setting are structural issues, data-driven research, academic leadership, and knowledge transfer. We discuss each focus area in more detail in the next section.

Discussion

Structural Issues

Some of the most important influences on engineering students' pathways through four year colleges are structural: admissions, curriculum, sequencing and scheduling of classes, credit

hours, faculty pedagogy, diversity of the faculty, classroom climate. And it may be easy to recognize these issues when depicted and explained in a structural framework that maybe perceived as abstract, distant concepts. However what is less easy is to acknowledge a role and discuss or impact change on these issues within the structure when using terms such as racism, sexism or classism.

Why are we so uncomfortable using terms such as racism? Perhaps when we use the term racism, people feel that we are making a critical and negative judgment about them as individuals. Another reason may be level of comfort. We are reluctant as engineers to address this issue head on, access the literature, and discuss such topics in a way that will gain a better understanding of racism in the same way sociologists do, for example. However, by not naming racism, we allow racism to persist.

Data Driven Research

Data driven research is crucial to elucidate many pathway impediments in engineering, inform the community and move toward strategies for improvement. It is important that this research takes multiple forms: large quantitative studies, small qualitative investigations and personal self-reflections. We need to expand the categories of data we collect, where possible, including generation in college status, veteran status, disability, LGBTQA (lesbian, gay, bi-sexual, transgender, queer or questioning, and ally or asexual). We also need to collect demographic variables aligned with our current understanding of people's experiences and identities. For instance, we need to mindful of modern definitions of gender including gender fluidity and transgender. With detailed, modern categories, we would have the data to analyze through the lens of intersectionality, which emphasizes intersections between forms or systems of oppression. Intersectionality studies disaggregate categories such as "underrepresented minority" and "women," which hide the experiences and stories of distinct groups such as Latino males and African American females. We realize gathering this data is difficult in engineering given the small populations of some groups, but this is not an excuse and underscores the need for multi-institutional data sets[4,5] and qualitative research focused on small numbers.[6,7,8]

As we broaden the definition of diversity and consider more groups or more dimensions, we should be mindful that we still have much work to do for groups whom we have been failing for years specifically African Americans/Black and Latino/as.

Academic Leadership

We believe academic leaders such as administrators and faculty have control over many structural and institutional impediments to diversifying the pathways of engineering students. When leaders believe change is necessary and become involved, the process of change can begin on fronts such as hiring more diverse faculty, changing admission to attract diverse students, and fostering an inclusive environment. Therefore, we may need basic research focused on administrators and faculty to examine engagement and beliefs around these matters. This research may include investigating faculty beliefs about problems such as structural and institutionalized racism, heteronormativity and sexism. For instance, research may identify their positions on the attitudinal continuum of antagonist to aware to ally to advocate on various dimensions of diversity and inclusion. Another area of research could be strategies to move individuals along this continuum.

Knowledge Transfer

Examples of effective practices informed by evidence are necessary to serve as catalysts for ideas for faculty and administrators as they seek models to transfer to their institutions. There may be useful examples from educational institutions and models from industrial practice that may improve the impediments discussed above. The recent book *Solving the Equation: The Variables for Women's Success in Engineering and Computing*[9] describes the example of Harvey Mudd College, where changing institutional structures and environments increased the representation of women. This book summarizes research in the engineering workplace showing culture was the major reason why women stayed or left an engineering career. The book also provides recommendation for actions targeted at specific groups such as employers, men in engineering and computing, women in engineering and computing, university administrators, government, parents, and policy makers.

Therefore, we call for more examples and models supported by research and the adoption and/or adaptation of these examples and models. We further acknowledge the need to adapt knowledge transfer models into practices for administrators and faculty that take into account unique organizational contexts.

Conclusion

We have highlighted and discussed four foci related to improving and diversifying engineering pathways in college: structural issues, data driven research, academic leadership and knowledge transfer. We look forward to receiving input from the community to advance the discussion.

References

1. Besterfield-Sacre, M., and L.J. Shuman (2016). Innovation through Propagation II: A Roadmap for Engineering Education. In *Proceedings of the 2016 ASEE Annual Conference and Exposition, New Orleans, LA*
2 Foor, C. E., & Walden, S. E. (2009). " Imaginary Engineering" or" Re-imagined Engineering": Negotiating Gendered Identities in the Borderland of a College of Engineering. *NWSA journal*, *21*(2), 41-64.
3 Watson, K., & Froyd, J. (2007). Diversifying the US engineering workforce: A new model. *Journal of Engineering Education*, *96*(1), 19-32.
4 Ohland, M. W. & Long, R. A. (in press) The Multiple Institution Database for Investigating Engineering Longitudinal Development: An experiential case study of data sharing and reuse. *Advances in Engineering Education*.
5 Yoder, B. L. (2014). ASEE datamining application. http://www.asee.org/datamining.
6 Foor, C. E., Walden, S. E. ,& Trytten, D. A. (2007). "I wish that I belonged more in this whole engineering group:" Achieving individual diversity. *Journal of Engineering Education, 96*(2), 103-115.
7 Pawley, A. L. (2013, June). Learning from small numbers of underrepresented students' stories: Discussing a method to learn about institutional structure through narrative. In *Proceedings of the 2013 ASEE Annual Conference and Exposition, Atlanta, GA*.
8 Riley, D. M., & Pawley, A. L. (2011). Complicating difference: Exploring and exploding three myths of gender and race in engineering education. In *American Society for Engineering Education*. American Society for Engineering Education.
9 Corbett, C., & Hill, C. (2015). *Solving the Equation: The Variables for Women's Success in Engineering and Computing*, AAUW, Washington, D.C. http://www.aauw.org/research/solving-the-equation/