

Sociotechnical Systems View of Catalysts that Enable Underrepresented Minority Student Success

Priyadarshini Pennathur¹, Brissa Quiroz², Ann Bisantz³ and Louis Everett⁴
Chair: Arunkumar Pennathur¹

¹Industrial and Systems Engineering, University of Iowa

²Microsoft Corporation

³State University of New York at Buffalo

⁴University of Texas at El Paso

Academic institutions in the US have recently refocused their attention on Diversity, Equity, and Inclusion. This panel consisting of engineering faculty, administrators and industry professionals will discuss how colleges of engineering can approach the problem of recruiting, retaining, and graduating undergraduate underrepresented minority (URM) students by using a sociotechnical systems modeling approach. The main thrust of the discussion is how an academic organizational system such as a college of engineering can be broken down into a social system consisting of the people (students, faculty, staff and other stakeholders), and a technical system consisting of programs and initiatives for URM student success. Joint analyses of the social system and the technical system can then reveal systemwide barriers and opportunities for enabling URM student success.

INTRODUCTION

Educational institutions in the US have continued to devote attention and efforts as part of recent DEI initiatives to increasing the participation of URM students in STEM disciplines. Programmatically, colleges typically employ a top-down or a bottom-up approach for improving URM student success, but both these approaches come with advantages and disadvantages. Although a top-down approach can lend initial structure, leadership, and resource commitments, it may not necessarily lead to widespread adoption of programs and practices among stakeholders, particularly when diversity efforts can be viewed as add-ons and an afterthought. A bottom-up approach, although empowering for stakeholders due to its grassroots nature, may not gather enough momentum to become structural and institutional due to siloed efforts and a lack of visibility, and limited financial resources, among other weaknesses. Whether beginning top-down, or bottom-up, or with a mix of the two, if organizations knew what catalysts in their system would help them leverage and mobilize their existing latent or known capacities and identify new capacities, and if they knew how to identify those systemwide catalysts, they could structure their recruitment and retention efforts better.

One area of opportunity to identify catalysts is to employ a sociotechnical systems lens to examine the challenges in URM student recruitment, retention and success. Organizational design approaches (Aken, 2004; Dunbar & Starbuck, 2006; Romme, 2003) for assessment and change typically proceed by observing the practices in living and functioning organizations to develop solutions for change. Several organizational design models (Král & Králová, 2016) including the Model of Organizational Performance and Change (Burke & Litwin, 1992), McKinsey's 7S framework (Robert et al., 1980), the Comprehensive Model for diagnosing organizational systems (Cummings & Worley,

2014), the Sociotechnical systems approach (Taylor & Felten, 1993) and the Congruence Model for Organizational Analysis (Nadler & Tushman, 1980) have facilitated organizational design and change processes. Organizational design approaches broadly entail three different perspectives: (1) rational, (2) dialogical and (3) pragmatic. In rational design (Ansoff, 1980; Cross, 2000; Hammer & Champy, 1993; Harris & Raviv, 2002; Mintzberg, 1979; Simon, 1969), structural characteristics including roles, responsibilities, authority structures, processes and mechanisms to coordinate these are considered in the design. The selection of the design is rational, based on the constraints of the problem and the objectives of the organization. In dialogical approaches (Butcher & Clarke, 2003; Hickson et al., 1971; Mintzberg, 1983; Pfeffer, 1978), although structural characteristics still play the primary role, organizations are seen as a political system. Hence, the design focuses on building consensus among the top in the hierarchy. Finally, the pragmatic approach assumes complexity in problems, and is broader in considering aspects other than structural characteristics. The pragmatic approach uses reflection from people's actions and experience (Schön, 1983) for design. The sociotechnical systems approach combines both the rational and the pragmatic approaches. An engineering educational organization has distinct structural characteristics including key roles and responsibilities, and processes and mechanisms for ensuring URM student success, which lends it rational design characteristics. By the same token, people's skills, their activities, and their knowledge and experience largely determine the outcomes of the engineering educational organization, making it a pragmatic system as well.

This panel is composed of an interdisciplinary group of experts drawn from the engineering professoriate, professionals with industry experience, and administrators from colleges of engineering who will each discuss ways in which how the college of engineering is a sociotechnical

system, and how adopting a sociotechnical systems lens could lend new insights on how to recruit, retain and graduate URM students successfully. Specifically, the panel will address the following topics:

- Need for a sociotechnical systems view and lens in studying URM student recruitment and retention challenges
- Examples of catalysts in organizations that can enable URM student success from academic and industry points of view.
- Insights and learnings from implementing programs and practices for URM students in colleges of engineering and in industry highlighting the challenges and opportunities for human factors engineering in furthering DEI work.
- Insights into studying colleges of engineering as a unit of research, the barriers therein, and pointers on how to overcome the barriers.

PANELISTS

Dr. Arunkumar Pennathur, Chair

Dr. Arunkumar Pennathur is an Associate Professor of Instruction in Industrial and Systems Engineering at the University of Iowa. Prior to joining Iowa, he was an Associate Professor of Industrial Engineering at the University of Texas at El Paso. Dr. Pennathur's engineering education research while at the University of Texas at El Paso, has been extensively funded by the National Science Foundation (NSF). Dr. Pennathur is a PI in a recent research project also funded by NSF, in which he and his colleagues, P. Pennathur and E. Blosser, have begun examining organizational dynamics in a predominantly white college of engineering, using a sociotechnical systems lens. The goal of the research is to model the social and technical subsystems at work in the college and identify barriers and enablers for URM student success.

As Panel Chair, Dr. Arunkumar Pennathur will introduce the panel members and the topic. He will also facilitate discussion among panel members and the audience to emphasize the need for human factors-based methods such as the sociotechnical systems approach to studying the organizational dynamics involved in enabling successful DEI efforts particularly to help URM students succeed in STEM.

Dr. Priyadarshini Pennathur

Dr. Priyadarshini Pennathur is an associate professor in the Department of Industrial and Systems Engineering at University of Iowa. Her research focuses on cognitive work, health IT and healthcare worker safety integrating perspectives, principles, and methods from cognitive engineering. She is a scientific editor in Applied Ergonomics and an associate editor of IISE Healthcare Systems Engineering journals. She is collaborating with Dr. Arunkumar Pennathur and colleagues on a recent NSF grant investigating URM student recruitment and retention challenges. She participates in college-wide efforts to

incorporate DEI best practices in faculty search committee discussions during hiring.

In this panel, Dr. Pennathur will share insights on how a socio-technical system approach could help understand misalignments between top-down and bottom-up approaches to organizational design and overcome barriers to success in URM student recruitment and retention. She will also share insights on potential catalysts that could promote success in URM student recruitment and retention based on data from the ongoing study and a previous study with undergraduate engineering students.

Dr. Brissa Quiroz

Dr. Brissa Quiroz is the University Relations Lead for Microsoft, supporting Hispanic Serving Institutions and Historically Black Colleges. Prior to her role at Microsoft, Dr. Quiroz was a full-time Engineering Lecturer and served as the Director of the Valley Industry Partnership for Cooperative Education in the Lyles College of Engineering at Fresno State University. In that role, she developed and supported strategic relationships with agricultural and manufacturing companies throughout California and Central Valley by working to fulfill their employment needs with engineering and construction management student interns. These companies, in turn, provided students the opportunity to learn from real world problems and to gain hands-on experience with a competitive salary, preparing them for permanent employment. Dr. Quiroz has served as co-PI of a \$2,638,250 NSF grant "The AAGEP California State University Underrepresented Minority STEM Faculty Alliance Model: A Culturally-Informed Strengths-Based Approach to Advance Early-Career Faculty Success, and has coordinated a \$2,996,913 grant from the US Department of Education titled STEAM: Enriched Pathways. Dr. Quiroz' professional career is centered on serving as a bridge between her passion for STEM and community outreach and education. Her ultimate goal is to empower every student to succeed in college, and especially, help increase recruitment and retention of students in higher education including low income and minority groups. Dr. Quiroz has a BS degree in Industrial Engineering, an MS degree in Industrial Technology and a PhD in Environmental Science and Engineering. She is the President of the Society of Women Engineers San Joaquin Valley Section and is on the Board of Directors for the ASEE Corporate Industry Partnership Division.

Dr. Quiroz will bring two unique perspectives to the fore in this panel discussion – one, that of a URM student, and two, that of an industry-university relations lead focused on diversity. Dr. Quiroz' journey, first as a URM undergraduate student herself, and then as a graduate student and a doctoral degree recipient, and now an accomplished educator, industry mentor and a champion for URM student success, will add richness to the discussion from her unique lived experiences.

Dr. Ann Bisantz

Ann Bisantz has made substantial contributions to the field of human factors engineering, including investigating new

techniques for displaying complex and uncertain information to decision makers; supporting the transition in complex work domains from legacy and manual information systems to more integrated, supportive IT systems; modeling human judgment and decision making; extending cognitive engineering methods which can be used to model complex human-technology work domains; and understanding aspects of human trust in automated systems. Dr. Bisantz also has a distinguished record of education and academic service contributions which have had significant impact on students, the university and her research field. Since 2018, she has served the University at Buffalo as Dean of Undergraduate Education through which she provides university-wide leadership regarding the academic experience for over 20,000 undergraduate students and oversees undergraduate curriculum and policy development. Her office is responsible for UB's general education program (UB Curriculum), undergraduate experiential learning, the Center for Excellence in Writing, and UB's Honors College. As a faculty member, she developed and taught a number of fundamental and advanced undergraduate and graduate courses in Human Factors Engineering and Industrial Engineering that have been highly regarded by her students. She has advised or mentored 60 MS and PhD students (a large percentage of whom are women or otherwise underrepresented in STEM) many of whom have gone on to successful academic or research careers. In 2020 she was named Mentor of the Year by the HFES WOMAN group, and 2017 she was awarded the Fitts' Education award from HFES for her contributions to human factors education. As the ISE Director of Undergraduate Studies (2003-2009) she was responsible for student advisement and curriculum development, and led a successful accreditation of the undergraduate degree program. As Department Chair (2012-2018), she hired or promoted 15 faculty members, successfully launched new graduate and undergraduate programs, and invested in and oversaw major improvements to undergraduate and graduate laboratories supporting teaching and research. She is the past recipient of an NSF CAREER award, was recognized with a SUNY Chancellor's Award for Research and Creative Activity, and is a Fellow of the Human Factors and Ergonomics Society.

Dr. Bisantz will share insights on how a systems engineering mindset can help in development of inclusive curriculum and pedagogy across diverse curricula and subject to various levels of constraints (state education, university system, campus, program, and accreditation) and constituent goals; and describe an iterative design approach to enhance student success in first-year STEM gateway courses.

Dr. Louis Everett

Louis Everett, Ph.D., P.E. is presently Associate Dean for Undergraduate Studies and Academic Affairs at the College of Engineering at the University of Texas at El Paso (UTEP). He is also the MacGuire Distinguished Professor of Mechanical Engineering at UTEP. Previously, he has held other key roles in colleges of engineering including Associate Dean and Acting Dean of Engineering at the American University of Sharjah, Undergraduate Program Director of Mechanical

Engineering, and Chair of the Department of Mechanical Engineering. Professor Everett has also been a NASA Administrator's Fellow at the Jet Propulsion Laboratory and has been a technical staff at the Bell Labs, IBM and NASA Johnson Space Center. Most recently, he was a Program Director at the Division of Undergraduate Education in the National Science Foundation and oversaw grants that furthered undergraduate STEM education. Professor Everett's research interests in engineering education involve helping underprepared STEM students merge into an Engineering Degree program and matriculate in minimal time and at minimal cost. His research initiatives in engineering education have been funded by the National Science Foundation through several phase 1 and 2 NSF-CCLI and IUSE projects. Having been a faculty member in Texas A & M University, and UTEP, and having been in various administrative roles in colleges of engineering, Professor Everett brings a wealth of knowledge and insights into the inner workings of colleges of engineering. He began his academic journey at UTEP as an undergraduate student in mechanical engineering, obtained his MS degree from Stanford University, and his PhD from Texas A&M University, and is now back at UTEP as a professor and associate dean in engineering.

Given his wide-ranging personal and professional academic journey and experience, for this panel, Professor Everett discuss how UTEP has transformed itself recently into a Carnegie Research Tier 1 institution while serving a majority Hispanic student population in the US-Mexico border region. He will share his insights into how organizations and people in organizations (particularly colleges of engineering) can think about balancing access (to education for students who are first generation) and excellence (in education and research), and what institutional structures can enable this balance.

ACKNOWLEDGEMENTS

The work discussed by Drs. Arunkumar Pennathur and Priya Pennathur is based upon their work supported by the National Science Foundation under grant No. (2042363). Any opinions, findings, and conclusions or recommendations expressed in this work are those of the authors(s) and do not necessarily reflect the views of the National Science Foundation.

REFERENCES

- Aken, J. E. van. (2004). Management research based on the paradigm of the design sciences: The quest for field-tested and grounded technological rules. *Journal of Management Studies*, 41(2), 219–246.
- Ansoff, H. I. (1980). Strategic issue management. *Strategic Management Journal*, 1(2), 131–148.
- Burke, W. W., & Litwin, G. H. (1992). A causal model of organizational performance and change. *Journal of Management*, 18(3), 523–545.
- Butcher, D., & Clarke, M. (2003). Redefining managerial work: Smart politics. *Management Decision*.
- Cross, N. (2000). *Engineering design methods: Strategies for product design*. John Wiley & Sons Inc.

- Cummings, T. G., & Worley, C. G. (2014). *Organization development and change*. Cengage learning.
- Dunbar, R. L., & Starbuck, W. H. (2006). Learning to design organizations and learning from designing them. *Organization Science*, 17(2), 171–178.
- Hammer, M., & Champy, J. (1993). *Reengineering in corporation. A manifesto for business revolution*. HarperBusiness, a division of HarperCollins publisher.
- Harris, M., & Raviv, A. (2002). Organization design. *Management Science*, 48(7), 852–865.
- Hickson, D. J., Hinings, C. R., Lee, C. A., Schneck, R. E., & Pennings, J. M. (1971). A strategic contingencies' theory of intraorganizational power. *Administrative Science Quarterly*, 216–229.
- Král, P., & Králová, V. (2016). Approaches to changing organizational structure: The effect of drivers and communication. *Journal of Business Research*, 69(11), 5169–5174.
<https://doi.org/10.1016/j.jbusres.2016.04.099>
- Mintzberg, H. (1979). The structuring of organizations. Englewood Cliffs. J: Prentice-Hall.
- Mintzberg, H. (1983). *Power in and around organizations*. Prentice Hall.
- Nadler, D. A., & Tushman, M. (1980). Frameworks for organizational behavior. *Organizational Dynamics*, 9(2), 35–51.
- Pfeffer, J. (1978). *Organizational design*.
- Robert, W., Peters, T. J., & Phillips, J. R. (1980). Structure is not organization. *Business Horizons*, 23(3), 14–26.
- Romme, A. G. L. (2003). Making a difference: Organization as design. *Organization Science*, 14(5), 558–573.
- Schön, D. (1983). The reflective practitioner basic books. New York.
- Simon, H. A. (1969). The sciences of the artificial MIT Press. Cambridge, MA.
- Taylor, J. C., & Felten, D. F. (1993). *Performance by design: Sociotechnical systems in north america*. Prentice Hall.