2021 ASEE ANNUAL CONFERENCE
Virtual Meeting | July 26–29, 2021 | Pacific Daylight Time
Paper ID #32527

Engineering with Engineers: Fostering Engineering Identity

Dr. Yen-Lin Han, Seattle University

Yen-Lin Han is an Associate Professor in the department of Mechanical Engineering at Seattle University. Dr. Han received her BS degree in Material Science and Engineering from National Tsing-Hua University in Hsinchu, Taiwan, her PhD degree in Aerospace and Mechanical Engineering and MS degree in Electrical Engineering from the University of Southern California. Her research interests include micro-scale molecular gas dynamics, micro fluidics, and heat transfer applications in MEMS and medical devices as well as autonomous vehicles and robotics. She is passionate about Engineering Education and experienced in developing inverted classroom lectures and facilitating students' learning through authentic engineering problems. She is currently the Co- PI for the NSF Revolutionizing Engineering and Computer Science Departments grant awarded to the Mechanical Engineering department at Seattle University to study how the department culture changes can foster students' engineering identity with the long-term goal of increasing the representation of women and minority in the field of engineering.

Dr. Kathleen E. Cook, Seattle University

Kathleen Cook, Ph.D. is a Professor in the Psychology Department at Seattle University. Dr. Cook received her doctorate in Social and Personality Psychology from the University of Washington, with a minor in quantitative methods and emphases in cognitive and educational psychology. Her research has included classroom learning, identity, and person perception.

Dr. Gregory Mason P.E., Seattle University

Gregory S. Mason received the B.S.M.E. degree from Gonzaga University in 1983, the M.S.M.E. degree in manufacturing automation from Georgia Institute of Technology in 1984 and the Ph.D. degree in mechanical engineering, specializing in multi-rate digital controls, from the University of Washington in 1992. He worked in a robotics lab for the Department of Defense for five years after receiving his M.S.M.E. He is currently a Professor in the Department of Mechanical Engineering at Seattle University, Seattle, WA. His research interests are controls system and the use of technology to enhance engineering education. Dr. Mason is a member of the American Society of Engineering Education and the Society of Manufacturing Engineers. He is a licensed professional engineer.

Dr. Teodora Rutar Shuman, Seattle University

Professor Teodora Rutar Shuman is the Chair of the Mechanical Engineering Department at Seattle University and an Affiliate Professor at the University of Washington. She is the PI on a NSF-RED grant "Revolutionizing a Mechanical Engineering Department through Industry Immersion and a Focus on Identity". Her research also includes NOx formation in lean-premixed combustion and electro-mechanical systems for sustainable processing of microalgae. Her work is published in venues including the Journal of Engineering Education, IEEE Transactions on Education, Bioresource Technology, Chemical Engineering Journal, Proceedings of the Combustion Institute, and Combustion and Flame. She is a member of the American Society for Engineering Education and the Algae Biomass Organization. Dr. Shuman served as Chair for the ASEE Energy Conversion and Conservation Division.

She received a Dipl.Ing. degree in mechanical engineering from Belgrade University, and an M.S.M.E. and a Ph.D. from the University of Washington.

Dr. Jennifer A. Turns, University of Washington

Jennifer Turns is a Professor in the Department of Human Centered Design & Engineering at the University of Washington. She is interested in all aspects of engineering education, including how to support engineering students in reflecting on experience, how to help engineering educators make effective teaching decisions, and the application of ideas from complexity science to the challenges of engineering education.

Engineering with Engineers: Fostering Engineering Identity

Introduction

The Mechanical Engineering Department at Seattle University was awarded the National Science Foundation (NSF) Revolutionizing Engineering and Computer Science Departments (RED) grant in July 2017 to support the development of a program that fosters students' engineering identities in a culture of doing engineering with industry engineers. The project capitalizes on the Department's strong connections with industry to cultivate a culture of "Engineering with Engineers" through changes in four essential areas: a shared department vision, faculty, curriculum, and supportive policies.

This paper reports the status of the five-year project and is an updated version from our previous NSF Grantees Poster papers presented at the 2018, 2019, and 2020 ASEE Annual Conferences. The project background and objective are unchanged; hence, the first two sections of the paper are combined from our previous papers [1] - [3]. The project description section contains a summary of the four areas of change that continue to guide our efforts, and updates the actions taken in each of the four areas. The remaining sections of this paper discuss ongoing evaluation, research, and future work.

Background

Identity influences who people think they are, what they think they can do and be, and where and with whom they think they belong [4] - [7]. People's identity shapes the experiences they embrace, and reciprocally, those experiences shape their identities [8] - [10]. People behave consistently with their identities [11], [12], choosing behaviors with meanings that match their self-conceptions [13], [14]. When people identify with an esteemed group, they feel better about themselves and, in turn, feel better about the group [15], [16]. If people strongly identify with a group, they are steadfast, defending the group, staying in the group, and supporting the group [17].

In education, identity influences whether people feel they belong in a program and what they believe they can achieve. It has been shown to influence what goals are pursued and the level and type of effort put towards those goals [12]. Research also shows that identity and fit are important factors affecting persistence in STEM fields [8]. When people perceive a fit between themselves and their fields, they persist longer in those fields [18] - [20]. Hence, identity is a determining factor in one pursuing, persisting, and persevering in engineering [11], [21].

The development of identity is a social process. People's thoughts and behaviors are shaped through relationships and reflected appraisals with others [5], [17], [22]. Identities are further derived through associations, affiliations, and identifications with groups [18], [23]. Tonso [24] observes that identity development is an enculturated process where identities are acquired through "community-based interactions" and Beam et al. [21] concur that social contexts affect identity. In engineering education, situated learning is central to identity development [24]. Therefore, this social process of identity development can be realized through the culture of an

engineering program. Cultivating a culture of doing engineering can result in graduates who not only are prepared technically and professionally with a practical, realistic understanding of what it is to be an engineer, but also who identify with and are committed to the engineering profession.

Objective

The project's objective is to develop a mechanical engineering program where students and faculty are immersed in a culture of doing engineering with practicing engineers from industry that in turn fosters students' engineering identities. The culture of a program plays a significant role in effective, innovative STEM education [25], [26]. The culture of "Engineering with Engineers" is being built through the interactions of students, faculty, and industry, through participation in engineering-related activities, and through reinforcement of shared similarities. We are studying how this new culture affects the identities of students and faculty, and how these enriched identities affect students' engagement in and commitment to engineering.

Project Description

Culture is shaped, in part, by the identities of those in the culture. It is negotiated, co-created and reinforced through communication and social interactions [27]. It develops organically from the behaviors of a group through association and shared experiences [28]. It is also important to know that culture in an educational setting is influenced by the priorities of the institution and department. Hence, we are creating this new culture of "Engineering with Engineers" in two ways. First, a variety of actions are being implemented to support these types of shared experiences to cultivate this new culture. Second, a number of changes to the structure and priorities of the program are being pursued.

To organize the actions and changes needed for this new culture, we follow the best practices recommended by Henderson et al. [29]. These include having coordinated efforts applied over extended periods of time, providing regular feedback and opportunities for reflection, changing faculty conceptions (e.g., their identities), providing incentives for change, and enacting policy changes from the ground up. From an extensive review of articles on facilitating change in STEM education, Henderson et al. indicated four areas of change: shared vision, reflective faculty, relevant curriculum and pedagogy, and supportive policies. In the following sections, the recent actions taken to realize changes in each of these areas are summarized. For details of our earlier efforts, please see references [1] - [3].

Shared Vision: Building a Culture that Cultivates Identities as Engineers

Goal:
Through interaction and discussion, the faculty agreed to establish a culture of "Engineering with Engineers." Specifically, the mechanical engineering department will be a hub of engineering activity where faculty, students, and industry can share experiences and ideas. The department also will forge relationships with key professional societies and utilize those relationships to create ties with local industries. As a small department with only nine full-time faculty, the goal is for all faculty to be involved in this project and to change this culture together.

Current status:

a. Sustained a shared vision. A shared vision is an important foundation for a culture. In an early stage of the project, the faculty and students worked together to establish a shared vision that would reflect the goal of fostering engineering identity. Guided by this shared vision, the Department took many actions described in the rest of this paper.

b. Established the department mission. Together the Department updated our mission statement:

> *[The mission of the SU Mechanical Engineering Department is to] Provide a technically rigorous design-focused education in a collaborative environment that emphasizes individual attention and connections to industry, while preparing students to help create a more just and humane world.*

This new mission statement helped us sustain our shared vision and underlined important aspects of our work.

c. Confronted issues related to inclusion. Past reports from our external evaluators, Inverness Research, revealed instances in which students did not feel included. The situations pointed out in these reports served as an alarm that raised faculty awareness of diversity, equity and inclusion (DEI) issues. Faculty and staff members attended training in DEI-related practices. A diversity and inclusion syllabus statement was discussed and adopted by faculty. This statement has been adopted and promoted by the College and we are hoping to see more faculty from other departments include this statement in their syllabi. Here is the statement:

> ***SU MECHANICAL ENGINEERING DEPARTMENT DIVERSITY AND INCLUSION***
> *Seattle University and the Department of Mechanical Engineering are committed to creating and sustaining an inclusive culture that values diversity and works for equity in opportunity and outcomes. Diversity is a core value we espouse as part of our mission. We respect our students' identities and we strive to create a learning environment where every student feels welcomed and valued.*
>
> *We ask for your help in fostering a welcoming and open environment, treating others with respect, and collaborating toward equity. Please refer to the Student Code of Conduct and to the Office for Diversity and Inclusion for more information and guidance. If you personally experience bias, harassment or discrimination, or witness any of these, you are encouraged to reach out to your instructor, your advisor, the Mechanical Engineering Department office, the College Advising Center, Diversity, Equity, and Inclusion Student Ambassadors (Instagram: su_stemdei), or any of the resources listed on the SU Diversity and Inclusion resources page including the Office of Institutional Equity.*

d. Elevated ME Student Advisory Council. The Student Advisory Council continued to provide a path for creating a shared vision with students. The Chair met virtually with students twice per quarter. During the pandemic, it was especially important to receive student input on Department actions and to hear directly from students how they were doing.

e. Implemented the revised student advising procedure. In our Department, each student meets with their assigned faculty advisor three times a year (each term). These meetings and relationships between the student and their faculty advisor are key to the cultivation of the

culture and to students' perceptions of themselves as engineers. Faculty discussed and agreed upon an advising process and a checklist that would promote connections between students' and the program's goals. Details of the advising process and checklist can be found in Ref. [3]. The uniform advising procedure, specifically during the pandemic, ensured students were cared for consistently across the Department.

f. Supported student mentors. Continuing to foster the community when we were physically apart was an important but difficult task. The Department supported student group activities and encouraged seniors to mentor other students. The Department also supported virtual study halls in which students could seek guidance from their peers.

Reflective Faculty: Strengthening Interaction with Industry & Understanding Diversity and Inclusivity

Goal:
To strengthen faculty's connection to industry and aid their ability to facilitate student connections, faculty will participate in an industry immersion experience during the summer where they work with practicing engineers and learn current industry practices. Additionally, faculty will acquire relevant industrial and teacher trainings. Ultimately, faculty will see their role, or identity, as moving students towards becoming practicing engineers who create a "more just and humane world." Students, too, will reflect on their identities as engineers and how those relate to their education and career paths. To bridge course work and industry practices, an Industry Advisor with extensive experience in industry and passion for engineering education will be on campus one day a week to provide insights to faculty and students.

Current status:
a. Faculty industry immersion. The grant provides opportunities for each faculty member to spend one summer month in industry [1]-[3]. Thus far, two faculty members have participated in the summer industry immersion program, which has broadened faculty views and strengthened their ties to industry. Although the Faculty Immersion program was interrupted by the pandemic, other faculty members plan on joining the immersion in the coming summers.

b. Faculty training. Faculty have attended multiple training courses since the beginning of the project. In the past year, the Center of Faculty Development, the Project Center, and the Center for Digital Leaning and Innovation at Seattle University led various training courses on topics such as inclusive pedagogy, building relationship-rich classroom experiences, and effectively moving our courses online. Some faculty also attended workshops hosted by professional societies such as ASME (American Society of Mechanical Engineers) to expand their DEI understanding, increase classroom engagement, and explore opportunities to involve more industry and professional societies in engineering curricula.

c. Industry Advisor. Since the Industry Advisor, who has extensive experience in industry and is passionate about sharing his experience with students, was added, students have been seeking his advice in many ways [1]- [3]. He has remained available, albeit online, during the pandemic.

d. Changes prompted by the pandemic. The pandemic gave faculty an opportunity to reconsider approaches and deliver courses differently. It also prompted faculty to broaden how they interact and engage with students. Many faculty members adapted inverted classroom pedagogy and implemented remote laboratories to continue the emphasis of "doing engineering". In addition, interactions with industry seemed to be easier due to the online format – practicing engineers from all over the country could join students in various courses virtually. Faculty utilized online communication tools such as Zoom and Microsoft Teams to host their office hours, advise and mentor students, or have one-on-one conversations with students in need.

Relevant Curriculum and Pedagogy: Maintaining Strong Connections with Industry and Incorporating Industry Practice into the Program

Goal:
Across the mechanical engineering curriculum, there will be connections to industry and student engagement in activities that reflect what a practicing engineer might do. Such connections and activities require pedagogic changes to existing courses as well as the implementation of a series of new courses with components related to industry practice. In addition to curriculum changes, the department encourages and sponsors regular seminars, social events, and design challenges to connect the program and industry more closely.

Current status:
a. Implemented the new ME curriculum. The Department's shared vision of "Engineering with Engineers" guided the curriculum revision. Details on the new curriculum and its development can be found in references [2] & [3]. The academic year 2019-20 was the first year with new curriculum. We discuss the main changes in the new curriculum below.

1. Vertically integrated design project courses (VIDP). Our program has a strong senior design course sequence where seniors work for an entire academic year in teams on real projects sponsored and mentored by industry. Real industry design experience, however, was missing in the first three years of the program. Hence, a separate design course sequence, where freshmen, sophomores, and juniors come together each spring to work on authentic design projects mentored by practicing engineers, was added to the curriculum. In this new VIDP sequence, integrated teams consisting of freshmen, sophomores and juniors learn practice skills such as design principles, team dynamics, project management, communication, etc., through experiential learning. An added benefit is that having freshmen, sophomores, and juniors work together on the same project naturally fosters a community feeling, enhances a sense of belonging, and strengthens identities.

The first VIDP courses were offered in the spring of 2020. Although the pandemic changed how the course was delivered, we were able to keep the essence of our goal and adapt to the online format. We report more details of these adaptions in another ASEE 2021 Conference paper [30]. For this online, pandemic version of VIDP, teams proposed a design related to COVID-19. Although the design teams could not build any physical parts, they had exercises guiding iterations of design principles. Additionally, each design team regularly met with their industry advisors; these volunteers from industry found it more convenient to connect with students virtually than traveling to meetings. In addition to traditional course assessments, students

completed an inclusion survey at the beginning, in the middle, and at the end of the term. Students felt a greater sense of belonging and inclusion with both their teams and the Department at the end of the term.

2. Data acquisition courses. The Department combined the electrical engineering and instrumentation courses into a single two-course sequence in the third year of our new curriculum. In the old curriculum, students took a circuits course in the winter quarter of their junior year and an instrumentation course the following spring quarter. When surveyed, students who had taken these two courses did not see the connection between the electrical engineering content and their mechanical engineering major courses. Thus, in the new sequence, electrical engineering and instrumentation are taught side-by-side using relevant mechanical engineering problems. Students learn an electrical engineering (EE) concept and apply it to instrumentation and data acquisition (DAQ) in the same week. To emphasize "doing engineering", the new sequence incorporates more labs than the previous two courses. Each week, there are two lecture/laboratory combinations, one for EE and one for DAQ. EE content is discussed in a 50-minute lecture followed by a 100-minute laboratory early in the week, and a 50-minute DAQ lecture and 100-minute laboratory occurs later in the week. The EE and DAQ content are well coordinated with laboratory exercises connected to in-lecture examples. The content of this two-course integrated sequence is presented in Ref. [31].

During the first offering of this sequence in 2019-20, all but the last week of the first course was in-person, and the second course was entirely remote. Modifications made to implement the lectures and labs remotely can be found in Ref. [30].

The goal of this two-course sequence is to provide an integrated experience for students where they learn electrical engineering concepts, apply the concepts to instrumentation, utilize precise measurements, and apply what's learned to their other mechanical engineering courses. Thus far, we have collected assessment data from bi-weekly reflection exercises, online engineering notebooks, and comprehensive exams, and are in the process of analyzing the data. Results from these assessments will be reported in a future paper.

3. Changes to the senior design course sequence. The program's senior design course sequence has had great success in connecting seniors and industry for more than 25 years. In the past couple of years, we implemented changes to make the experience more like industry practice. Changes such as the vocabulary used, the removal of traditional academic schedules, and the addition of project status check-ins are detailed in Ref. [3]. With these changes, students felt more empowered to guide their projects.

In the past year, while we continued with these changes, we also added exercises to raise the awareness of diversity, equity and inclusion. We implemented the following:
(i) Asked each team to establish "team norms and team contracts". This exercise helped foster communication and positive interactions within teams. Teams were asked to revisit their team norms constantly as the project went on.
(ii) Implemented an "inclusivity meter". The inclusivity meter was a weekly survey that asked, "Do you feel included in this week's meeting with your team?" It not only allowed the senior

design coordinator to closely monitor issues that may arise but also provided an avenue for students to voice their concerns. More details of the "inclusivity meter" can be seen in [32].
(iii) Utilized Microsoft Teams. There was a dedicated Teams channel for all senior design teams to communicate virtually. Students were able to ask questions via different channels and chat on MS Teams.
(iv) Used MURAL (www.mural.co) to collect comments/questions during status check-in presentations. After each presentation of a team's monthly progress, there was two minutes of "quiet time" for everyone – students and faculty – to post their comments/questions on MURAL. Then the presenting team could select a couple of questions to answer on the spot. Students felt they could voice their opinions more freely and equally using MURAL and had an opportunity to receive more in-depth feedback from their peers and faculty.
(v) Hosted virtual Projects Day and end-of-quarter conference. Projects Day at the end of each academic year celebrates students' achievements. Due to pandemic, the Projects Day was moved online in the spring of 2020. Students gave live presentations and answered questions from a live audience via Zoom. Because it was virtual, more attended Projects Day than when it was in-person. Similarly, we hosted an end-of-quarter virtual conference in the fall of 2020. All sponsor liaisons attended the virtual conference and were deeply engaged in discussions with student teams. Students also received valuable suggestions from the conference attendees.

b. Innovative teaching. The pandemic allowed faculty to adapt different teaching approaches and revamp our classes. Many instructors inverted their classes. Because students watched recorded lectures before class, class time was used to work on problems and projects. Digital Whiteboard, MURAL, OneNote, or Google Docs were used to help students collaborate online. Some remote labs gave students the same hands-on learning experiences as we were in-person by sending students lab kits and having students acquire small components themselves [30]. Other labs were online, and faculty created videos of equipment and, separately, of conducting the experiment. Extra time created by not conducting the experiment in person allowed for deep learning in other ways. After submitting a pre-lab assignment and watching the video with detailed description of experimental equipment, students were given longer time to brainstorm potential outcomes of the experiment than if they were conducting it. During the same lab period and after they watched the video of the experiment conducted by the faculty, they were given more time to process the data, and understand and explain physically what happened. This resulted in better written lab reports than in the in-person course offerings. The fully online environment was also an opportunity for in-depth viewing and touring of facilities that would not have been possible when large groups of students physically move through spaces, and for some instructors to invite practicing engineers from all over the world to give guest lectures and share the latest practices in their respective fields.

c. Industry seminars and socials. Even though we could not meet in-person, we continued to host events so that speakers/mentors from industry could share their experiences with students. Some faculty also joined virtual happy-hours and socials hosted by students to make students feel connected to the department even when we were physically apart.

Supportive Policies: Changing Expectations in Departmental Reviews

Goal:
Culture takes time to grow organically, and changes cannot be forced. Building a shared vision warrants a solid foundation for the project. Reflective faculty and changes to curriculum create pathways for change. Activities that bring faculty, students and industry together enhance the community-based interactions and, in turn, cultivate the culture of doing engineering. Supportive policy will play a role in motivating and sustaining changes.

Current status.
The department has worked closely with other departments, the college and the university to develop supportive policies.

a. College-wide and University-wide efforts on diversity, equity and inclusion: As mentioned previously, the College has recommended the diversity and inclusion statement developed by the Department to all senior design courses offered in the College as well as to all other courses. As an extension of the DEI work the Department has championed, the Department advocated for a College "ombudsman" to support students. These Student Advocates, as they are now called, reside in the College Advising Center and support any student in the College who may experience discrimination, inequity, or exclusion. The Department will continue to work with the Student Advocates to refine their role and responsibilities, combat biases, and build a more inclusive culture in the College.

In September 2020, the university began an initiative, "LIFT SU: Inclusive Excellence Action Plan for Racial Equity and Antiracism 2020-2021". The principles of LIFT are: Listen and learn, Impact through intentional action, Fail forward, and Transform together [33]. Our department lives with these principles and is committed to the actions outlined by the LIFT initiative.

b. Changes to the annual performance reviews. The Department modified our annual performance review process to incentivize and motivate faculty and to recognize and commend faculty's engagement with industry, the changing culture, and curricular and pedagogical revisions. The College has already recognized the value of various types of service faculty do in our annual performance review form. We also worked closely with the SU ADVANCE team to revise the university policies on tenure and promotion to recognize contributions in different areas a faculty could have [34]. The proposed tenure and promotion guideline from ADVANCE is in the final process of getting approval from the campus community.

Evaluation and research

Goal:
During this project, changes to the program and to student and faculty identities are evaluated through interviews, surveys, portfolios, reflections, and audio and/or video documentaries. All students and faculty in the program are invited to participate in these evaluation activities and responses are tracked every year to document the changes.

The three main research questions this project aims to study are:

1. How have the identities of the students and faculty changed?
2. How has the departmental culture changed?
3. What happened in response to the changes made and the changes that occurred?

Current status:
a. Identity surveys and Implicit Association Tests (IATs). We continued to collect survey data to track how student's identity changes, using both the explicit identity surveys and the Implicit Association Tests (IATs). Details and baseline results of these surveys can be seen in references [35] and [36]. More results of these identity studies will be presented in future conferences.

b. Alumni and senior exit surveys. We have developed tools to track how students' experiences impact them after they leave the program. Graduating seniors and alumni are invited to participate in tailored online surveys annually.

c. Growth in professional skills. To document the impact of the changes to senior design on students' professional thinking and skills, a pre-post assessment was developed. The pre-test was administered at the start of the 2019-20 senior design sequence. The post survey was administered in June 2020. Preliminary results showed improvement in students' growth. For example, students felt more confident to "treat failures and setbacks as opportunities to learn," and "recognize important gaps in existing information and takes steps to eliminate those gaps." We are continuing the same format in Engineering Design courses in 2020-21 and are conducting the pre-/post-test again.

d. Inclusion surveys. In addition to developing skills relevant to senior design, the VIDP courses bring students of different cohorts together. The expectation is that these shared experiences working together will increase students' sense of being included in their teams and in the Department. An inclusion survey was administered three times across the VIDP quarter. Results showed that students felt more a part of their teams and the Department by quarter's end.

e. Reflections. Short reflection activities were added to some classes. These reflection exercises not only add a means for students to understand their work, but also help document student's personal growth.

f. External evaluator interviews. An external evaluation team is monitoring the process and progress of culture change in the department by interviewing faculty and students in the department every year. From these interviews, the external evaluator provides their suggestions related to the subject of culture change and the department discusses those suggestions at the beginning of each academic year to determine our action items. Additionally, the change process is also being documented via audio and videos of faculty interviews. Those videos/audios will be the basis of a documentary of our journey in changing the culture at the end of this project.

Future Work and Long-Term Goals

We are changing the culture of our department in the four essential areas of shared vision, reflective faculty, relevant curriculum and pedagogy, and supportive policies. The unifying theme of these changes is a connection with industry and a focus on identity. In the remaining

years of this project, we will continue taking actions in these four areas to sustain changes we have begun. We will also broaden our dissemination phase by inviting visiting scholars to witness changes in our program.

A focus on identity encourages reflection and a larger discussion about how students and faculty see themselves, their education, and their profession, and how experiences uniquely affect underrepresented or marginalized students. Researchers have suggested that culture is especially important for women to persist in a field [24], [35]. A culture of "Engineering with Engineers" with incentives and training that promote industry engagement and build strong industry-education connections is essential for technically and professionally prepared graduates with a practical, realistic understanding of what it is to be an engineer. But we also need a culture that allows all graduates to identify with and commit to the engineering profession. We have invested significant effort in building an inclusive culture and environment, something we all appreciate is important in today's climate.

It is our hope that our work will provide a clearer understanding of the changes that promote engineering identities and how such identities affect students' sense of belonging in a program and their persistence in the major. We hope that this conversation about engineering identity can lead to a better understanding of how best to create an inclusive environment for all.

Acknowledgement

This project was funded by the NSF IUSE/PFE: RED grant #1730354.

References

[1] Y.-L. Han, K. E. Cook, T. R. Shuman, G. Mason, and J. Turns, "Engineering with Engineers: Revolutionizing Engineering Education through Industry Immersion and a Focus on Identity," *Proceedings of American Society for Engineering Education Annual Conferenc*e, Salt Lake City, UT: ASEE 2018.

[2] Y.-L. Han, K. E. Cook, G. Mason, T. R. Shuman, and J. Turns, "Engineering with Engineers: Revolutionizing a Mechanical Engineering Department through Industry Immersion and a Focus on Identity," *Proceedings of American Society for Engineering Education Annual Conference,* Tampa, FL: ASEE 2019.

[3] Y.-L. Han, K. Cook, G. Mason, T. R. Shuman, and J. Turns, "Engineering with Engineers: Fostering Engineering Identity through Industry Immersion," *2020 ASEE Annual Conference and Exposition*, Montreal, Québec, Canada: ASEE 2020.

[4] K. Deaux, "Reconstructing social identity," *Personality and Social Psychology Bulletin,* vol. 19, pp. 4-12, 1993.

[5] S. Stryker, and P. J. Burke, "The past, present, and future of an identity theory," *Social Psychological Quarterly*, vol. 63(4), pp. 284-297, 2000.

[6] E. H. Erikson, *Identity and the life cycle*. New York: International Universities Press, 1959.

[7] M. B. Brewer, "The social self: On being the same and different at the same time," *Personality and Social Psychology Bulletin*, vol. 17, pp. 475-482, 1991.

[8] J. E. Dutton, J. M. Dukerich, and C. V. Harquail, "Organizational Images and Member Identification," *Administrative Science Quarterly*, vol. 39(2), pp. 239-263, 1994.

[9] G. H. Mead, *Mind, Self, and Society*. Chicago: University of Chicago Press, 1934.

[10] S. Stryker, *Symbolic Interactionism: A Social Structural Version*. Menlo Park, CA: Benjamin/Cummings, 1980.

[11] J. D. Lee, "More Than Ability: Gender and Personal Relationships Influence Science and Technology Involvement," *Sociology of Education*, vol. 75(4), pp. 349-37, 2002.

[12] B. R. Schlenker, "Identity and self-identification.," in *The Self in Social Life*, B. Schlenker, Ed. New York: McGraw-Hill, 1985.

[13] J. D. Lee, "Which Kids Can "Become" Scientists? Effects of Gender, Self-Concepts, and Perceptions of Scientists," *Social Psychology Quarterly*, vol. 61(3), pp. 199-219, 1998.

[14] O. Pierrakos, T. K. Beam, J. Constantz, A. Johri, and R. Anderson, "On the development of a professional identity: Engineering persisters vs. engineering switchers," *Proceedings of Annual Frontiers in Education Conference*, San Antonio, TX: FIE, 2009.

[15] R. B. Cialdini, R. J. Borden, A. Thorne, M. R. Walker, S. Freeman, and L. R. Sloan, "Basking in reflected glory: Three (football) field studies," *Journal of Personality and Social Psychology,* vol. 34, pp. 366-375, 1976.

[16] H. Tajfel, and J. C. Turner, "The social identity theory of inter-group behavior," in *Psychology of Intergroup Relations*, S. Worchel, & W. G. Austin, Eds. Chicago, IL: Nelson-Hall, 1986, pp. 33-48.

[17] R. Spears, B. Doosje, and N. Ellemers, "Self-stereotyping in the face of threats to group status and distinctiveness: The role of group identification," *Personality and Social Psychology Bulletin,* vol. 23, pp. 538–553, 1997.

[18] S. E. Cross and N. V. Vick, "The Interdependent Self-Construal and Social Support: The Case of Persistence," *Personality and Social Psychology Bulletin*, vol. 27(7), pp.820-832, 2001.

[19] A.L. Kristof, "Person-Organization Fit: An Integrative Review of its Conceptualizations, Measurement, and Implications," *Personnel Psychology*, vol. 49(1), pp.1-49, 1996.

[20] O. Pierrakos, N. A. Curtis, R. D. Anderson, "How salient is the identity of engineering students? On the use of the Engineering Student Identity Survey," *Proceedings of Frontiers in Education Conference*, Erie, PA: FIE, 2016.

[21] T. K. Beam, O. Pierrakos, J. Constanz, A. Johri, and R. Anderson, "Preliminary findings on freshmen engineering students' professional identity: Implications for recruitment and retention," *Proceedings of American Society for Engineering Education Annual Conference*. Washington, DC: ASEE, 2009.

[22] C. H. Cooley, *Human nature and the social order*. New York, NY: Scribners, 1902.

[23] K. E. Scheibe, "Historical perspectives on the presented self," in *The Self in Social Life*, B. Schlenker, Ed. New York: McGraw-Hill, 1985.

[24] K. Tonso, "Enacting practices: Engineer identities in engineering education," in *Engineering Professionalism: Engineering Practices in Work and Education*, U. Jørgensen and S. Brodersen Eds. Rotterdam, The Netherlands: Sense Publishers, 2016, pp. 85-104.

[25] C. Henderson and M. H. Dancy, "Increasing the Impact and Diffusion of STEM Education Innovations", *Increasing the impact and diffusion of STEM education innovations,* Washington, DC: National Academy of Engineering, 2011. [Online]. Available: https://www.nae.edu/File.aspx?id=36304. [Accessed: 15- Nov- 2016].

[26] M. Besterfield-Sacre, M. F. Cox, M. Borrego, K. Beddoes and J. Zhu, "Changing Engineering Education: Views of U.S. Faculty, Chairs, and Deans," *Journal of Engineering Education*, vol. 103(2), pp. 193–219, 2014.

[27] J. N. Martin and T. K. Nakayama, *Intercultural Communication in Contexts*, New York: McGraw-Hill, 2010.

[28] J. Lave and E. Wenger, *Situated learning: Legitimate peripheral participation*, Cambridge UK: Cambridge University Press, 1991.

[29] C. Henderson, A. Beach, and N. Finkelstein, "Facilitating change in undergraduate STEM instructional practices: An analytic review of the literature," *Journal of Research in Science Teaching,* vol. 48(8), pp. 952-984, 2011.

[30] Y.-L. Han, J. Hammel, C. Strebinger, E. Gilbertson, G. Mason, K. Cook, K., T. R. Shuman, and J. Turns, "Making the "New Reality" More Real: Adjusting a Hands-On Curriculum for Remote Learning", *2021 ASEE Annual Conference and Exposition*, Long Beach, California: ASEE 2021. *Abstract accepted.*

[31] Y.-L. Han, G. Mason, K. Cook, K., T. R. Shuman, and J. Turns, "WIP: Integrating Electrical Engineering Fundamentals with Instrumentation and Data Acquisition in an Undergraduate Mechanical Engineering Curriculum," *2020 Frontier in Education (FIE) Conference*, Uppsala, Sweden: IEEE 2020.

[32] K. Mejia, Y.-L. Han, and J. Turns, "Inclusivity Meter: Tracing How it Worked and What Was Learned," *2021 ASEE Annual Conference and Exposition*: ASEE 2021. *Abstract accepted.*

[33] https://www.seattleu.edu/newsroom/stories/2020/lift-su-bolsters-seattle-us-inclusive-excellence-action-plan-for-racial-justice-and-anti-racist-education.html, [Accessed: 21-Feb-2021].

[34] Award Abstract #1629875, "ADVANCE Institutional Transformation at Seattle University". Washington DC: National Science Foundation, [Online]. Available: https://www.nsf.gov/awardsearch/showAward?AWD_ID=1629875&HistoricalAwards=false. [Accessed: 08- Apr- 2018].

[35] K. E. Cook, Y.-L. Han, G. Mason, T. R. Shuman, and J. Turns, "Work-in-Progress: Engineering Identity across the Mechanical Engineering Major", *Proceedings of* A*merican Society for Engineering Education Annual Conference*. Salt Lake City, UT: ASEE 2018.

[36] K. E. Cook, Y.-L. Han, G. Mason, T. R. Shuman, and J. Turns, "Implicit Engineering Identity in the Mechanical Engineering Major". *Proceedings of* A*merican Society for Engineering Education Annual Conference*. Tampa, FL: ASEE 2019.