Changing the Landscape of the Digital Workforce and DEI: A Call to Action for Engineering Education

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Abstract

Digital transformation has been implemented across a wide range of industries. Advanced technologies (e.g., artificial intelligence, robotics, cloud, internet of things etc.) and data are used to digitally connect organizations, automate processes, and represent each aspect of complex systems, products, and services. While digital transformation has changed the landscape of the engineering workforce, engineering programs of today remain largely based on 20th-century needs. Due to the interdisciplinary nature and interconnectedness of digital transformation, the traditionally siloed engineering disciplines require innovation to keep pace with the workforce demands. This paper explores the digital transformation workforce demands and digital competencies that are needed now and for the future of the engineering workforce. These skills extend beyond the technical, but also encompass social, emotional, and higher cognitive skills. Further, digital transformation will have a tremendous impact on diverse communities - with the opportunity to either create access or create further disparity due to access to engineering education and opportunities beyond. The paper also reports on the experiences and advice of participants in the invited panel that was held at the 2023 ASEE Southeastern Regional Conference where panelists addressed the need to modernize engineering education in the era of Digital Transformation and the strategies they envision or have implemented to address opportunities and risks for diversity, equity, and inclusion.

Introduction

Rapid advances in digital technologies have had a tremendous impact throughout the economy. Digital transformation is offering opportunities for a wide range of industries, enabling collaboration across time and place, among stakeholders throughout the life cycle of products and systems, between industry, community, and educational institutions, to name a few. Advanced technologies (e.g., artificial intelligence, robotics, cloud, internet of things etc.) and data are used to digitally connect organizations, automate processes, and represent each aspect of complex systems, products, and services. Digital technologies provide opportunities for shared information, efficiencies in services, and automation, like no other time in history.

While much progress has been realized, there remain significant technological challenges and unanticipated societal challenges thanks to digitalization. Standards for data, information, and knowledge representation, cyber security, protection of intellectual property, the integration of human and machines, and shortages of talent prepared to work in and contribute to the fast-changing digital landscape are needed. Workforce development and shortages are significant with needs for talent at all levels. For engineers in particular, workers need to be able utilize and advance technology, excel in the interdisciplinary nature of complex engineering problems, within interconnected digital spaces, make decisions, and be versed in 'soft skills' required for collaboration and communication.

Traditionally, undergraduate and graduate engineering education has been siloed according to disciplinary departments. Students navigate their education through a series of courses intended to prepare them via methods and tools that define the discipline. This approach is based largely on 20th-century needs. While team-based and project-based learning has grown in engineering curricula, such experiences remain small relative to the rapidly changing demands of digitalization. Interdisciplinary programs and/or degrees are growing but limited. Team-based projects are often from a single discipline. Courses in advanced technologies are increasing, but often specific to a particular method or tool, rather than with a systems integration approach.

This paper explores the digital transformation workforce demands and digital competencies that are needed now and for the future of the engineering workforce. The paper also addresses the impact that digitalization poses for diverse communities - with the opportunity to either create access or create further disparity due to reduced access and costs to participate. In the sections that follow, background is presented first, with a focus on industrial revolutions and a definition of digital transformation. This is followed by a section that addresses changing workforce demands, skills and competencies. Next, a call-to-action section takes on several topics and strategies that are essential to advances needed to meet the needs of digitalization and to avert the unintended, but very real, risks for students from underrepresented communities in engineering.

To enrich and support the discussion on these topics, an invited panel comprised of distinguished thought leaders in digitalization and engineering education was hosted at the 2023 ASEE Southeastern Regional Conference in March of 2023. Panelists' contributions addressing the need to modernize engineering education in the era of digital transformation and the strategies they envision or have implemented to address opportunities and risks for diversity, equity, and inclusion are included in the Call-to-Action section. A link to the recording of the panel is also included. Conclusions and future work are also offered.

Industrial Revolutions and Digital Transformation

Over the past two centuries, the world has undergone four industrial revolutions with the fifth on the horizon. Each was powered by disruptive new technologies. In the 18th century, Industry 1.0 transformed manual production methods to machines that used steam and waterpower. Industry 2.0 occurred a century later with the electrification and mass production that transformed factories into modern production lines. The invention of computer technology in the 20th century led to the automation era of Industry 3.0. Today, Industry 4.0 is marked by advanced technologies that are connecting people, processes, digital technologies, and data by integrating the digital and physical worlds [1], [2], [3], [4].

Nine key enabling technologies typically characterize Industry 4.0. These include: additive manufacturing, augmented reality, autonomous robots, big data and analytics, cloud computing, cybersecurity, horizontal and vertical system integration, industrial internet of things, and simulation [3]. These technologies have been the driving force behind digital transformation. While initially focused on cyber-physical systems within a manufacturing industry. Today, Industry 4.0 extends beyond a single manufacturing industry, encompassing the value chain across industries [5].

Following quickly behind, Industry 5.0 builds upon and extends Industry 4.0 by augmenting digital transformation with more meaningful and efficient collaboration between humans and machines and reinforces the role of industry within a larger societal context. Digital transformation continues to change the way that people live, work, and the way that organizations operate. It is enabling organizations to become more intelligent and efficient, optimize their operations, reduce costs, and innovate new products and services [4].

Digital Transformation, at the heart of Industry 4.0 and 5.0, has been defined as: "a process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies [6]." This definition is widely embraced in practice and is utilized throughout this paper.

Changing Workforce Demands, Skills and Competencies

Digital Transformation has impacted the workforce of the future through a combination of automation, transforming the nature of work, and an emphasis on skills development. Digital work is the new normal. Automation technologies (i.e., advances in robotics and artificial intelligence) are used to improve efficiency, streamline and replace manual human tasks, and create improved experiences for customers and employees [7]. While automation may make some jobs obsolete, it will also increase the demand for new roles and decrease the demand for others [8]. The World Economic Forum predicts that 85 million jobs will be displaced by automation. On the other hand, they forecast that 97 million jobs will be created to support advances in technology, which demonstrates a net positive effect for digital transformation [9].

Automation, in tandem with the COVID-19 pandemic introduced new demands that forced innovation and changes in the way work is performed. Some examples include replacing traditional work practices with the need to work and interact remotely, digital collaboration, and faster adoption of advanced technologies (e.g., use of cloud technologies, investments in cybersecurity) and online learning and training [9].

Digital Transformation is also changing the skills needed to perform work. The advancements in technology have created a demand for employees to possess digital skills. While the demand for skills is high, the talent supply is low, and companies struggle to find the talent to fill digital roles [10]. One-third of the critical skills by 2025 will consist of technology competencies that are not being considered today, and two-thirds of skills considered important today will change. An estimated 50% of all employees will need reskilling due to adopting new technology by 2025 [11], [5].

Digital skills and competencies are needed to live and work in the digital age. A collaborative effort between LinkedIn and the World Bank examined 50,000 skill categories covering 100 countries across 148 industries. They defined the following four categories of digital skills [12], [13]:

- Basic technical skills: Digital literacy skills to access and use email and basic applications (e.g., Microsoft Office).
- Applied technical skills: Skills that require using enterprise software and platforms to improve job efficiency and performance)
- Software & hardware technical skills: Skills related to building software and hardware
- Disruptive technical skills: Skills required for designing and developing advanced technologies (i.e., artificial intelligence and robotics).

Others have expanded the list of competencies needed for digital transformation beyond digital skills. Based on their review and analysis of the literature, Iordache, et al., have identified thirteen (13) digital competency and skill frameworks that can be clustered into five common categories, including: 1) operational, technical, and formal; 2) information, cognition; 3) digital communication; 4) digital content creation; and 4) strategic [14].

There are several more recent frameworks, for example: Skills and Competencies framework (SkiCo) [15], Skills Framework for the Informational Age (SFIA 8) [16], and European Commission's Digital Competence Framework for Citizens (DigComp) [17]. These frameworks not only highlight the importance of technical skills, but also non-technical skills. There has also been an increased demand for social and emotional skills as well as cognitive skills (i.e., creativity, critical thinking, decision making and information processing) [10].

A Call-to-Action:

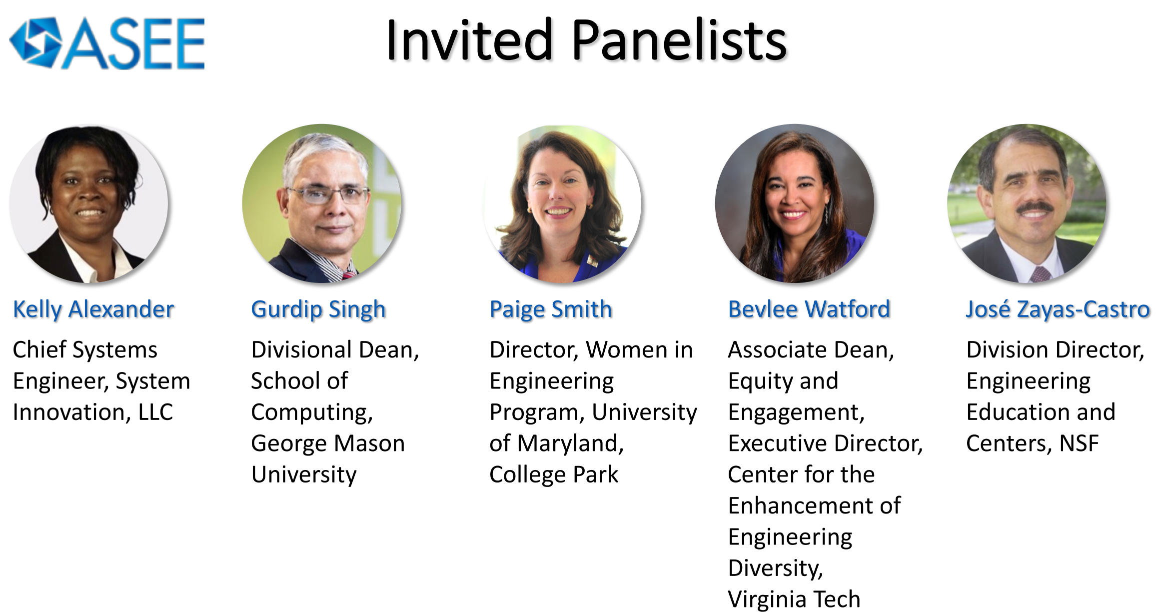
Following the trends of Industry 4.0 and 5.0, the pace of technology adoption will likely continue to accelerate. Although the number of jobs displaced may be surpassed by the number of jobs created to support advances in technology, skill gaps continue to be high. Companies face new challenges in talent shortages [10]. Engineering Education must adapt to prepare students with the skills necessary (technical, social, cognitive, and interpersonal skills) to thrive in the complex, digitally connected, and in the rapidly changing workplace and world [18].

This section puts forward a Call-To-Action with each subsection representing an area where efforts/actions are needed for changing the landscape of the digital workforce. The five topical areas include: Engineering Education Curriculum; Experiential and Interdisciplinary Learning; Educational Pathways to Engineering; Diversity Equity and Inclusion; and Partnerships.

As mentioned previously, a panel of distinguished speakers were hosted recently in an invited panel at the 2023 ASEE Southeastern conference, held in Arlington, Virginia. Highlights from panelists' discussion, shown in *italic font*, are included at the end of each topical subsection of this Call-to-Action section. The full recording of the panel was captured and can be viewed on YouTube. Readers will likely find the rich sharing of panelists goes well beyond the focus of this paper at times. We believe this recording is a wonderful resource.

ASEE Southeastern Panelists

The names and affiliations of the panelists are shown below. The Appendix section of this paper includes a brief bio sketch for each panelist.



Engineering Education Curriculum

While progress is being made in the modernization of engineering education curricula through project-based and problem-based learning implemented in select courses at the discretion of interested faculty, larger more comprehensive reform is much more modest. The National Science Foundation has incentivized reform through a variety of programs with associated funding for research and the implementation of change [19], [20]. Yet, when considering the number of engineering programs nationwide, comprehensive change throughout institutions of higher education has been modest. Industry, government, professional organizations, and engineering education researchers who have taken on the task of assessing the current state and needs of today's engineering graduates are growing. Findings indicate that largely, recent graduates are lacking skills needed to drive the economic transformation that is needed for nations to remain competitive [21]. Digital literacy and skill development is growing in curricula through courses that focus on topics such as artificial intelligence, data science, data analytics, computer science, machine learning, and more [22]. While promising, these courses tend to be offered, much like other courses in the curriculum, as offerings that increase knowledge of specific methods and tools, rather than providing students the opportunity to experience their education as a continuum and progression of knowledge that supports the integrated systems thinking mindset that is needed in an integrated/connected digital world.

A growing number of graduate programs offering doctoral degrees in engineering education have emerged since 2004, when Purdue University and Virginia Tech transformed engineering fundamentals divisions into departments, hired tenure track faculty who were passionate about research in engineering education, and developed Ph.D. degree programs. Doctoral programs that focus on the practice and research of engineering education, hold promise for advancing the methods, tools, and pedagogy of how engineering students are recruited, motivated, engaged, retained, and educated. For digital transformation, such research and insights from experts at the doctoral level in engineering education are critical, with contributions that are applicable throughout traditional fields of engineering. There are now 15+ doctoral programs and new master of science programs in engineering education. A growing trend includes collaboration between engineering and education colleges [23]. These programs provide promise for increasing the preparation of engineering educators at the K-12 level and in colleges/universities. While encouraging, such programs are few in number, given the need for change on the larger national scale.

From Panelists

On Curricula

Dr. Alexander recommended that universities should build digital literacy, skills, and competencies for students across subjects.

Dr. Singh emphasized the importance of systematic integration of digital technologies throughout the curriculum.

Several panelists comment on sociological needs, challenges, and even on the importance of the "joy of living" and how these are important to motivating and engaging student.

Dr. Zayas - Castro commented on the overly structured curriculum that exists in engineering. He goes on to comment about graduate school curricula in particular. Not only in engineering, but in medicine, business, and more. What do educators in non-education disciplines about educating? He uses examples from the challenges of educating during the pandemic. He also comments on the needs for interdisciplinary experiences. Wholistic experiences are far more engaging for students. He also comments on how politics can have negative impacts on education, including freedom of speech … topics that are and are not permitted. This is a significant challenge in the United States.

Dr. Alexander builds upon the discussion of highly structured curricula. She emphasizes how important it is to infuse digital transformation. It will happen anyway. Hence, the need to be purposeful, act with deliberation, and to plan ahead.

On Distance Education

Several panelists comment on the significance and challenges of distance education.

On Educating Educators

Dr. Watford emphasizes how important educating educators is … they are challenged to educate differently, yet are not prepared to do so. She also comments on how long 'active learning' has been part of engineering education transformation, but questions how pervasive or well *implemented such approaches are on a large scale. Students are not responsive to 'old' methods. We must learn how to teach using the tools and methods we are challenging students to learn. She uses the VLOOKUP function in Excel as an example. How many professors are versed in this and many other tools that are far more advanced?*

Dr. Watford later comments on how curricular change does not need to happen all at once. Indeed, change an assignment, change a module, do this over time. She also reflects on how students do not do their homework. Why? Because faculty do not have the time to grade the assignments. She goes on to suggest the use of digital technologies to not only submit homework, but to grade it. She is certain that the practice of homework and feedback can only help. She also gave the example of using data analytics to assess student performance. Again, use the technology! Dr. Watford also offered that computer science students could take on how to develop electronic homework, how to grade it, and more. They need projects for their capstone projects. By taking advantage of expertise and collaborating with other departments and disciplines, we do not need to know and do everything. Collaboration is key. She also emphasizes the wealth of resources available to educators. Cool stuff found in YouTube videos and more.

Experiential and Interdisciplinary Learning

In its earliest incarnation, engineering education programs focused on practice. Apprenticeships and hands-on experience with shop work were common. The early 1900s saw a shift to more theoretical and mathematical analysis in the curriculum. Spurred by technology needs of WWII and early space programs, engineering then took on a science-based focus. In more recent years (1990s and beyond), engineering education has seen a shift to the importance of design and problem solving. The approach has been to educate by specific engineering field [24].

Largely, students have relied on internships and coop programs to gain experience in the field. Capstone design projects with external clients are also common in engineering curricula, providing students opportunities to work on real problems with external clients. It is very common for students to reflect on these experiences highlighting a greater sense of clarity about engineering and its application. Indeed, when asked about their favorite or most impactful experience at the time of graduation, it is common that students highlight internship, coop and capstone design experiences. Outside of capstone design, real world experiences that are implemented within the curriculum are most often at the discretion and within the comfort level of the faculty instructing courses. Faculty who have partnerships with industry may take on an integrative approach to their teaching, research, and service. Collaborators may be from a variety of sectors, such as manufacturing, service, healthcare, transportation, etc.. This type of integration of efforts has seen an increase in recent years as promotion and tenure committees (department, college, and university levels) who have traditionally siloed approaches to evaluating research, teaching and service by independent 'counting' of contributions are becoming more open to integration and blurring boundaries. In addition to problem-based and project-based learning, some have studied the use of case studies to provide realism to student learning [25]. While there are benefits, case studies do not provide the same level of student motivation and engagement that is possible through in-person engagement with external collaborators [26].

At the undergraduate level, most engineering departments are intent on having degree programs that are accredited by ABET [27]. This offers confidence to students, their families, and employers, that graduates have received a quality education that has met the standards of the discipline. Unfortunately, maintaining accreditation has caused many administrators of single discipline degree programs to be less than enthusiastic about fully embracing interdisciplinary approaches to engineering education or creating interdisciplinary degrees. While ABET is receptive, the fear of change and how it might impact accreditation is very real. A modest number of capstone design courses provide for interdisciplinary team experiences, with most expressing concerns about whether interdisciplinary projects satisfy all needs for accreditation of their single disciplinary program. While there has been an increased interest and creation of multidisciplinary degree programs by faculty at the undergraduate level in recent years [28], interdisciplinary and multidisciplinary experiences remain modest rather than common practice.

From Panelists

On Real World Context

Dr. Singh has found that students are motivated by solving real problems in context. Learning is also enriched when faculty has real world experiences. Dr. Singh highlighted the need for inspired teaching and inspired research.

He also comments on the evolution that has taken place in digitalization, and for the use of sensors and cyber-physical systems more broadly. How do we prepare students to embrace this? Approaches have been very focused and specialized. And certainly, have not been inclusive. With the transition to smart cities and communities, there has been a big impact on interests in digitalization. Dr. Singh brings the perspective of how important integration of real-world problems can be.

On Digital Transformation of Teaching and Learning

Dr. Watford has research activities focused on the recruitment and retention of students in engineering, with a particular emphasis on under-represented students. She recommends transforming teaching and learning to incorporate digital transformation concepts. (For example, how to teach differently using technology, how to automate using AI/ML traditional processes, how to use data analytics to understand and improve performance, etc).

On Experiential Learning

Dr. Alexander comments on the importance of hands-on learning opportunities. She relays how digital is ubiquitous now. She emphasizes how context helps to integrate digital into systems thinking and digital literacy and competency. She highlights competencies and organizations that are supporting this transformation. Her view is that all courses, even core courses such as English and more, should embrace digital literacy and systems thinking.

Dr. Smith questions how students learn about the communities they are designing solutions for? She describes a course that has been developed at the University of Maryland. She emphasizes how professors are co-constructing knowledge with students. They are not 'experts' and how this is okay. Students learn professional skills, learning how to have conversations with others who *are different, in backgrounds and more. Learning how to be comfortable with conflict and develop emotional intelligence. This is fundamental to working together and solving complex problems.*

Educational Pathways to Engineering

National demand for a technically skilled and educated workforce has been rising dramatically for more than a decade. Indeed, the National Science Board and National Academies of Sciences, Engineering, and Medicine predict workforce shortages to be in the millions [29], [30]. Universities have engaged in a variety of strategies to increase the pipeline/pathway into STEM fields and to increase student success. Outreach programs that introduce engineering to children are common. Engaging current engineering students and student societies in these activities is common. Summer programs for K-12 students have also grown in numbers over recent decades. Funding for such programs has come from the National Science Foundation, with an emphasis on development and implementation, coupled with research related to pedagogy, learning styles, teaming and collaboration and more. Industry and philanthropists, recognizing needs, have also contributed to funds for such programs. Professional engineering societies have also engaged in programs to increase interest and retention of students, including scholarships, support of outreach implemented by university student chapters, and more. Topics related to digitalization and Industry 4.0 tend to focus on activities that are physical in nature that can be visualized. Robotics and 3D printing (additive manufacturing) are increasingly used as demonstrations or projects that engage the interest of K-12 and university students [31], [32].

From Panelists

Dr. Smith discusses the importance and ways of connecting to community for real problems. She discusses a course related to teaching children (K-12) about the design realization process as well as manufacturing. Undergraduate students developed the kits that were used in K-12 outreach.

Dr. Zayas-Castro builds upon Dr. Smith's example and emphasizes the importance of establishing collaborative teaching teams, perhaps comprised of faculty across disciplines, K-12 teachers, students, and community partners. Partners can be across the world! Instructional technologies can be helpful to this. He emphasizes how librarians can be wonderful resources. He also uses sports analogies to emphasize the need for a team-based approach and partnerships.

Diversity Equity and Inclusion

Diversity, equity and inclusion (DEI) are critical to increasing the talent, perspectives, and skills so needed in the STEM workforce. Diverse backgrounds and perspectives can only increase the number of ideas and innovative solutions to engineered products and systems. While many universities throughout the nation have sought to understand and address DEI, successes remain modest. There are few universities who have seen significant progress. For the majority, the percentage of persons of color, women, Hispanics, and other underrepresented groups enrolled in and graduating from engineering programs has remained low, with little change, for decades. Investments in initiatives has risen, yet outcomes are not aligned. The Association of Public and

Land-grant Universities engaged in a study that provided insights into diversity across engineering education, where there has been progress in racial and gender equity and where progress is needed [33]. Quoting directly from the study, six findings include:

1. Despite large numerical increases for Hispanic and Black students, these two groups along with American Indian/Alaska Native (AIAN) and Native Hawaiian/Pacific Islander (NHPI) students remain significantly underrepresented in engineering at the undergraduate and graduate level.
2. From 2010-11 to 2015-16 there was a massive increase in Non-U.S. Resident graduates in engineering at all levels, especially master's degree where this group is now the majority of master's degree earners.
3. The gender disparity transcends URG and majority groups in similar ways with women earning fewer degrees than men, even though in 2015-2016, the majority of degree earners in all fields of study combined are female.
4. At the institutional level there is a high concentration of each URG in a small number of institutions which contrast with a large number of institutions with little to no racial or ethnic diversity in their engineering programs.
5. Historically Black Colleges and Universities (HBCUs) and Hispanic Serving Institutions (HSIs) continue to play an important role in educating Black and Hispanic students in engineering.
6. States with majority-minority or emerging majority-minority college age population are failing to educate a large enough share of their URG students in engineering.

Strategies that have been employed to increase the success of DEI efforts have been many and varied. Research has shown that where there is community and belonging, the successes are larger. For instance, a study found there to be a positive correlation between the diversity of faculty to that of the diversity and success of students [37]. Training the professorate in DEI has been a strategy that has increased significantly in recent years, recognizing that the majority of faculty lacked the tools to understand and implement best practices. Training materials, courses, workshops, and experiences that reward individuals and programs for increasing their knowledge and skills in DEI have grown significantly in recent years. These have been in-house and external to universities [34]. Indeed, ASEE has several diversity and inclusion initiatives that support and incentivize the community [35].

Preparing the next generation to fill the needs of the digital workforce poses unique opportunities and challenges for diversity, equity and inclusion. For example, digital technologies have the potential to connect and integrate individuals from very different backgrounds and cultures. Indeed, technology can assist collaborations that are international, with community partners, with industry, and beyond. Such experiences can assist educators with bringing real problems and real partners into project-based learning experiences. Digital technologies can also support systems thinking and problem solving through integrated environments, so that students can appreciate diversity of thought, disciplines, and much more. At the same time, digitalization poses a risk to DEI, through the unintentional exclusion of those from lower incomes and means. Computers, software, robots, 3D printers, and other technologies are expensive. Addressing access, including the costs, to individuals and to educational institutions of less financial means are issues that cannot be overlooked.

From Panelists

<u>On Innovation</u>

Dr. Smith is dedicated to promoting the role of women in the field of engineering with a focus on the recruitment and retention of undergraduate and graduate female engineering students. Dr. Smith highlighted the need to prepare students to navigate in an increasingly diverse society. Dr. Smith facilitates a course on cultural diversity through intergroup, dialogue, equity, and inclusion and engineering design. She co-creates knowledge with students to help them learn how to be more inclusive in the design process. This requires them to consider the communities for which they are designing for. This approach provides experiential opportunities to learn and utilize professional skills. Through learning and understanding about different cultures and different economic backgrounds, they gain the soft skills needed to relate to the people that will be using the products and services that they design.

<u>On Access and DEI</u>

Dr. Watford comments on how important it is that institutional resources are available to provide the technologies needed for students with financial need to participate.

Dr. Singh emphasizes the importance and opportunities availed through broadening participation, including NSF funded projects. He emphasizes the need to integrate research with education and also recognizes the 'value system' that exists in academia. It is important to bring resources (funding) to engineering education research and the wholistic approach to traditional areas of engineering research. Engagements with the community in education is important … research, summer internships, and moving research into education. Sustainability is imperative! Dr. Singh emphasizes how it is the same people who are truly in and they are few. This is why NSF requires broader impacts, so that DEI and other efforts are sustainable.

Dr. Zayas-Castro responds to an audience question about how top-down approaches are not working (i.e., envision and implement from the top). He emphasizes how important it is to understand and collaborate with other disciplines, including those who are educated and trained to be educators. He also makes the point of how reactionary approaches to infusing digital technologies and transformation will have an even greater impact on DEI. The 'have nots' will have even less without forethought and planning for how to address such challenges. We have a social responsibility. That is, how do we reduce the gap?

Dr. Kelly shares a personal story of how a student with mental health challenges was home schooled. This student had access to modular education, electronically graded assignments, and on-demand tutoring/help. She questions why such resources are not part of 'traditional' classrooms for K-12 students.

Partnerships

Both government and industry have a vested stake in supporting engineering education's digitalization. Industry depends on educated engineers to become employees. The US government also supports engineering education in the interest of national security and to fuel the economy of this country. It is paramount that we bring together government, industry, and academia to take on the rich experiences and opportunities needed in the preparation of the current and future workforce. Partnerships are critical to many of the other topical areas found in this Call-to-Action. Systems thinking, the richness of multidisciplinary problems and teams, and real problems with real customers have significant impact on student motivation, engagement, learning, and retention. Many students, particularly those who may have been weaker in traditional academics, will work harder and be more interested when working on a project for a 'customer' than they will for themselves or for their instructor/professor. Partnerships are critical to the STEM pipeline, realism and learning far beyond the classroom.

From Panelists

<u>*On Expanded Engagements*</u>

Dr. José Luis Zayas-Castro has developed partnerships with small businesses, industry, non-profit foundations, and international organizations. He encourages a systematic approach to building engagement. The digital age has expanded the boundaries of collaboration where partnerships are possible from anywhere around the globe. These engagements should consider partnerships across university departments, alumni, industry, global collaborations, government, academia, professional societies, and the local communities.

Dr. Watford emphasizes 'divides' that exist. First between engineering education research and engineering education practice. And too, she emphasized the division between what engineering students are taught/learn and what engineers do. These divides require attention. Partnerships are promising.

Dr. Kelly discusses how the Systems Engineering Research Center (SERC) helps to bring research problems from industry to universities. She emphasizes the richness of the experiences for students (undergraduate and graduate).

A question from the audience was posted to ASEE president, Dr. Jenna Carpenter, who happened to be present. The question focused on what is ASEE doing to support this topic. Dr. Carpenter provided an overview of several ways ASEE is engaged and reinforced the power of collaboration and partnerships. She supports open forums and panels for discussion and bringing the community together.

Another question comes from the audience related to how to share knowledge and resources. There was some discussion around building sustainable community resources. Several panelists contributed to this discussion. Active engagement from the community was encouraged. Do not rely solely on professional organizations like ASEE.

Conclusions and Future Work

Our premise, and the focus of this paper, is that as the world embraces the digital transformation of engineering, so too must engineering education in the preparation of the next generation of engineers. This is not only critical for meeting the needs of engineering practice in the digital era, but also for diversifying the engineering workforce through the inclusion of diverse talents, perspectives, backgrounds and experiences. Digitalization can enable interdisciplinary collaborations among academicians, industry and community. It can also pose risks and barriers to those with limited financial means and access. It is imperative that the opportunities and barriers be addressed throughout education pathways (K-12, higher education institutions, adult education and training, etc.). Government (local and national), industry, community, and educators at all levels must unite, collaborate and commit to the preparation of learners and the workforce of the future in this digital age.

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Appendix

Brief bio sketches of the five invited panelists are listed here in alphabetical order.

Dr. Kelly Alexander is the Chief Systems Engineer at System Innovation. She has over 35 years of experience in systems engineering and project management. Early in her career, Dr. Alexander was one of the first African American US Army engineering interns. As a US Department of Defense civilian, she served as the Director of Systems Engineering Policy and Program Support, Director for Common Operating Environment at HQ US Army, and spearheaded the transition of modular software into the US Army's tactical software. She also led the Army's digital transformation and modular open systems using open standards and open architectures. As a White House Leadership Fellow, she served as the Senior Technical Advisor for the Federal Permitting Council. Dr. Alexander is a three-time recipient of the Superior Civilian Service Award and two-time recipient of the Commander's Award for Civilian Service. Dr. Alexander earned a PhD in Systems Engineering from George Washington University, master's degrees from George Washington University (Systems Engineering) and National Defense University (National Resource Strategy), and a bachelor degree in Industrial Engineering from NC State University.

Dr. Gurdip Singh is the Divisional Dean for the School of Computing at George Mason University. He was previously Division Director for Computer and Network Systems in the CISE Directorate at National Science Foundation. He has also served as Associate Dean for Research and Graduate Programs of the College of Engineering and Computer Science at Syracuse University and as Department Head of Computer Science at Kansas State University. Dr. Singh earned his MS and PhD degrees in Computer Science from SUNY, Stony Brook in 1989 and 1991 respectively, and his B. Tech degree in Computer Science and Engineering from IIT Delhi in 1986. His research and teaching interests include real-time embedded systems, sensor networks, network protocols and distributed computing.

Dr. Paige E. Smith is the director of the Women in Engineering Program in the A. James Clark School of Engineering at the University of Maryland. She has over 25 years of experience with recruiting and retaining diverse populations in engineering. Under Paige's leadership, the Women in Engineering Program has received many awards for retention and outreach programming. From 2017-2020 she served as the Program Director for Broadening Participation in Engineering in the Engineering Directorate at the National Science Foundation. While at NSF she also served in a two-year rotation as the Implementation Team co-lead for NSF INCLUDES. Paige is a Past President of the Women in Engineering ProActive Network (WEPAN). Paige earned her Ph.D. and M.S. in industrial and systems engineering and B.S. in engineering science and mechanics from Virginia Tech.

Dr. Bevlee A. Watford, P.E. is a Professor of Engineering Education, Associate Dean for Equity and Engagement, and the Founding Executive Director of the Center for the Enhancement of Engineering Diversity (CEED) for the College of Engineering at Virginia Tech. Her research activities have focused on the recruitment and retention of students in engineering, with a particular emphasis on under-represented students. An active ASEE member since 1986, she chaired the Diversity Task Force that resulted in what is now known as the Commission for Diversity, Equity and Inclusion. She has served as ASEE President, President of the Women in Engineering ProActive Network (WEPAN), and as a member of the Board of Directors of the National Association of Minority Engineering Program Administrators (NAMEPA). She also served as a program manager in the Division of Undergraduate Education for the National Science Foundation, and as the program director for broadening participation in the Division of Engineering Education and Centers. In 2023, she was nominated by President Biden to serve on the National Science Board. She received her B.S. in Mining Engineering, and her M.S. and Ph.D. in Industrial Engineering and Operations Research from Virginia Tech.

Dr. José Zayas-Castro serves as Division Director for the Division of Engineering Education and Centers at the NSF (since August 2021). He is professor of industrial and management systems engineering in the University of South Florida (USF). During two decades at USF, he has served as a department chair, associate dean for research, associate dean for international affairs and executive associate dean in the College of Engineering. Previously, he was a professor and co-director of the diversity in engineering program at the University of Missouri-Columbia. He began his career at the University of Puerto Rico-Mayagüez (UPRM), held leadership positions, and led activities in manufacturing, innovation, and academic and research affairs. Zayas-Castro's interests are in healthcare systems engineering, manufacturing systems, economic and cost systems, engineering entrepreneurship, student learning, and broadening participation. He has developed partnerships with small businesses, industry, non-profit foundations, and international organizations. He received his bachelor's degree in industrial engineering from UPRM, and his master's in management engineering, MBA, and PhD from Rensselaer Polytechnic Institute.

Zayas-Castro is a Fellow of the Institute of Industrial and Systems Engineers and a member of the Pan-American Academy of Engineering. In 2006 he was a co-recipient of the Bernard M. Gordon Prize for Innovation in Engineering and Technology Education.