Received: 25 August 2018 | Revised: 14 March 2019 | Accepted: 20 March 2019
DOI: 10.1002/jee.20256

EDITORIAL

JEE
Journal of Engineering Education

The next Morrill Act for the 21st century

The Morrill Act of 1862 and the second Morrill Act of 1890 helped establish the land-grant universities and the historically black colleges and universities in the United States, and changed the landscape of higher education in the United States by making agricultural and technical education accessible to a wider range of students. Today, postsecondary Science, Technology, Engineering, and Mathematics (STEM) education is critical for obtaining employment in these relatively higher-paying fields (e.g., Fayer, Lacey, & Watson, 2017; Langdon, McKittrick, Beede, Khan, & Doms, 2011). Yet, access to STEM education varies by student demographic characteristics, such as sex, race/ethnicity, social class, and geography, such that large segments of our society are underrepresented in STEM fields, and in engineering specifically (National Science Foundation, 2017; National Science Board, 2018). We propose that a new Morrill Act is vital to increasing access to STEM education in the 21st century and to helping our diverse citizens meet the new challenges emerging from the rapid rate of global economic and technological changes. We envision the next Morrill Act for the 21st century, which includes increased federal funding for public higher education, and we describe why it is important and how the discipline of engineering education could play a significant role in helping to meet the goals of the next Morrill Act.

The Morrill Act of 1862 provided public lands and funding toward making agricultural and technical education accessible to the working class, local farmers, and people of all races—those who would otherwise not have been able to attend college at that time. The first Morrill Act (1862), the Hatch Act (1887), the second Morrill Act (1890), the Smith Lever Act (1914), and legislation in 1994 that extended land-grant status to tribal colleges in combination helped establish a public higher education system in the United States, which led to advances in agriculture and engineering—in effect, elevating the quality of life for many Americans and lifting college graduates into the middle class (Geiger & Sorber, 2017; Lee & Keys, 2013).

Today, there are more than 100 land-grant institutions across the United States, each with a commitment to providing agriculture and mechanic arts education to all without excluding other scientific and classical studies (Integrated Postsecondary Education Data System [IPEDS], 2018). Figure 1 shows the number of engineering degrees awarded by land-grant institutions by state. PhD degrees in engineering education are now awarded at several land-grant institutions, including Clemson University, Purdue University, The Ohio State University, Utah State University, and Virginia Tech. Research conducted by members of the growing engineering education research community can play a major role in improving and broadening access to engineering education across the spectrum of public higher education institutions over the next century.

Just as the Industrial Revolution spurred the first Morrill Act of 1862, the prevailing Digital Revolution, Information Age, and impending Fourth Industrial Revolution (Schwab, 2017) similarly call for new legislation to reaffirm our nation's commitment to making education accessible to its citizens and to meet the needs of the rapidly changing economy and workforce. Many believe that our nation is facing a skills crisis—that our country's education and job training programs have not kept pace with the rapid technological changes that we are facing and the emerging industries and workforce needs (Executive Order 13845, 2018; Fayer et al., 2017). Between 2005 and 2015, employment in STEM-related occupations grew at a faster rate than non-STEM jobs—24.4 versus 4.0%, respectively (Noonan, 2017). Nearly three-quarters of STEM workers have at least a college degree, compared to just over one-third of non-STEM workers (Noonan, 2017).

Since their founding, America's land-grant universities have strived to fulfill their democratic mandate for openness, accessibility, and service to people. Michigan State University, one of the first federal land-grant institutions, for example, expressed its mission as to democratize higher education and expand its opportunities based on merit, not social class; to find practical applications for scientific research and technological innovations; and to make public service an essential part of higher education's mandate (Michigan State, 2018). It is therefore timely and necessary for the next Morrill Act for the 21st century to further support the ability of land-grant institutions to meet their missions, as well as to extend the reach to include all public higher education institutions.

We propose this new legislation, the next Morrill Act for the 21st century, to increase public funding for all public higher education institutions toward strengthening STEM and liberal arts education. In the spirit of the first Morrill Act, the next

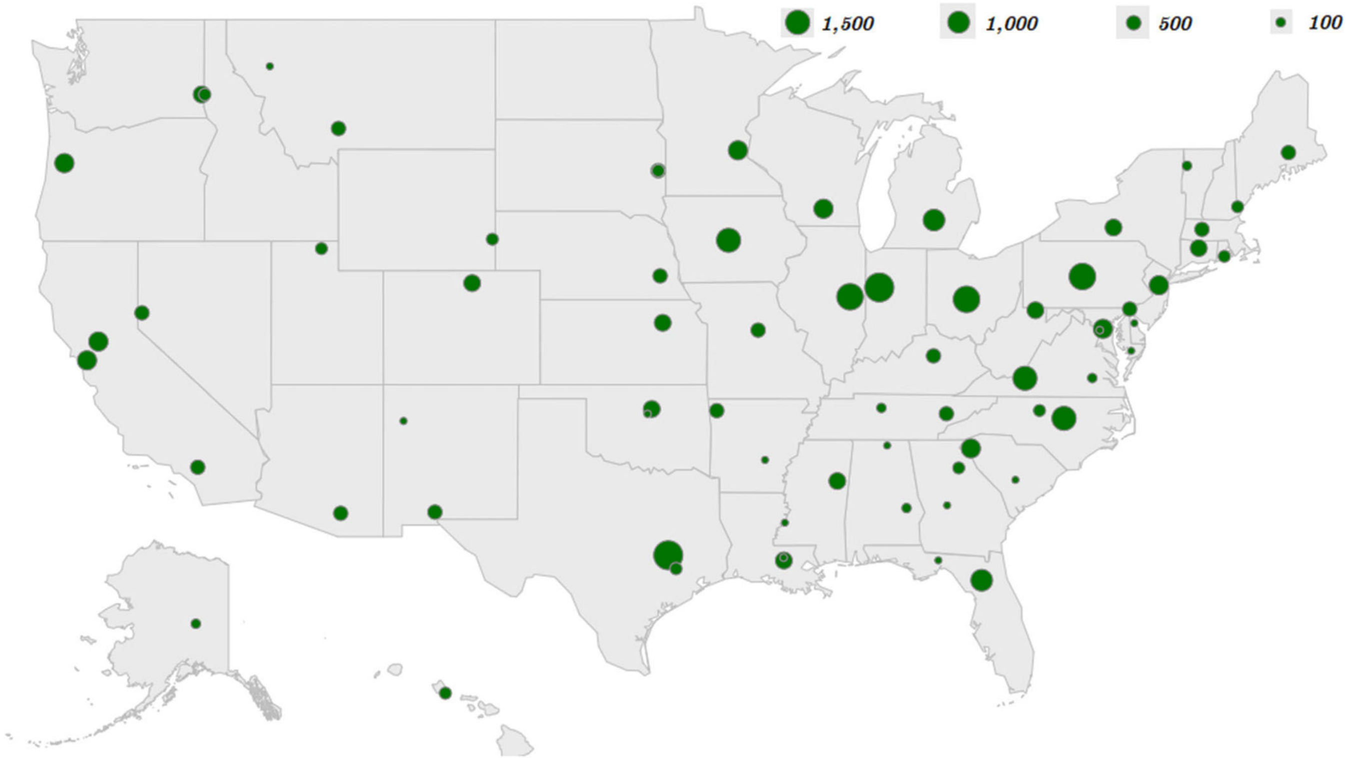

FIGURE 1 Number of undergraduate engineering degrees awarded per year by land-grant institutions in 2017. *Source*: Integrated Postsecondary Education Data System (IPEDS), 2018 [Color figure can be viewed at wileyonlinelibrary.com]

Morrill Act for the 21st century would likewise "promote liberal and practical education" at land-grant and other public higher education institutions. As technology becomes increasingly important in society, education in STEM fields, as well as in the liberal arts, is critical to understanding the impacts and implications of these technological changes. The role of public higher education institutions in STEM education, and engineering education specifically, is paramount. Public universities are a significant provider of STEM education. In 2017, 70% of all engineering undergraduate degrees were awarded by public colleges and universities (IPEDS, 2018), and 30% were awarded by land-grant institutions (IPEDS, 2018).

It is unclear what education and skill sets the 21st-century economy and emerging industries will require. What is clear, however, is that we need to prepare more citizens to be adaptable, lifelong learners who embrace ambiguities and uncertainties with new ideas and innovations. The next Morrill Act has the potential to (a) reaffirm the goals of the original act, (b) recommit the higher education system to those goals, (c) broaden accessibility to higher education, and (d) inspire citizens to embrace the land-grant mission. In particular, research conducted by engineering education programs can provide the tools to maximize the impact of the next Morrill Act.

While some citizens will obtain their introduction to lifelong learning while earning a college degree or other credential, universities also have other means to provide lifelong learning opportunities. Agricultural extension services were established under the Smith-Lever Act of 1914 to provide access to information informally through each land-grant institution. The modern technology age calls for establishing engineering extension services at each land-grant institution as well as other public academic institutions. Engineering extension services, for example, could provide access to the engineering expertise and resources of public universities to the citizens of each state. Similar to agricultural extension, outreach programs such as mobile laboratories and summer science camps focus on K-12 STEM education, and with increased funding, could provide additional precollege instruction in engineering as well as professional development opportunities for K-12 teachers who want to teach their students about STEM topics. Outreach programs can also focus on helping postsecondary faculty to innovate their engineering courses to reflect the newest effective instructional technologies and pedagogical approaches. Investing in teacher training in STEM could potentially enhance student interest in college engineering majors and, more importantly, could help increase student exposure to engineering and promote greater understanding of the impact of technology on society.

To broaden accessibility and inspire citizens to pursue higher education, we propose increasing the number of pathways into engineering education, to innovate the platforms through which citizens can access engineering education, and to engage all citizens in some level of engineering or other STEM education. Multiple pathways into engineering could include 2-year technical degrees, certificates, bachelor's degrees, and graduate programs for technical skills, as well as multiple entry points from K-12 through mid-career levels. Research and outreach efforts by engineering education scholars are promoting earlier introduction to engineering at the K-12 level, for example. Stronger connections and partnerships between K-12 and public academic institutions can also facilitate student interest in and access to STEM education. The distinctive difference that the next Morrill Act could potentially make is to establish more systematic connections with employers to determine which skills and competencies are needed for employment and success in emerging industries. Connections with employers could be through advisory boards, faculty/employee exchanges, or continuing conversations with alumni, to mention a few, and lead to revisions of K-12 and postsecondary curricula.

Whereas increasing access to practical education reached students who would have otherwise not been able to afford postsecondary education at the time of the first and second Morrill Acts, in the 21st century, we have to be deliberate about access to engineering education along multiple dimensions. For example, along the race/ethnicity dimension, it is critical to more purposefully engage Hispanic/Latino, African American, Native American, and other groups currently underrepresented in engineering education. Only with greater representation can we more responsibly and effectively address the myriad of societal challenges current and emergent in the 21st century (Hewlett, Marshall, & Sherbin, 2013; Phillips et al., 2014; Wulf, 2001).

Although we emphasize educating the engineer of 2050 in the U.S. context here, we hope that the next Morrill Act will accomplish more than that. In many ways, the American education system has led educational innovations worldwide. In 2014, the United States was the educational destination for 19% of the world's internationally mobile students (those who crossed a national border and moved to another country to pursue education) for tertiary education. The United States is also a top destination for internationally mobile students pursuing doctoral education; in 2015, academic institutions in the United States awarded 34% of their science and engineering doctoral degrees to international students on temporary visas (National Science Board [NSB], 2018). Thus, advancements in U.S. STEM education also have global impact and benefits through the many international students who earn their degrees at U.S. institutions. Further, STEM education and training contributes to worldwide growth in knowledge-intensive production and trade, as well as in research and development, interconnecting many nations (NSB, 2018).

Providing all of our citizens with some level of STEM literacy will contribute to maintaining the world's economic and societal well-being in the 21st century. The next Morrill Act will help establish a renewed emphasis on the goals of the original Morrill Act of 1862 with increased funding to focus on the needs of the 21st century—including preparing all of our citizens for the accelerating changes and uncertainty driven by increasingly complex technologies, information, and socially connected networks worldwide. As we envision it, the next Morrill Act will help our citizens meet the challenges of a rapidly changing economy and workforce needs. It will allow us to meet these challenges proactively, rather than reactively. It will facilitate new ways of thinking about and delivering engineering education to make it more accessible, more affordable, and practical for the emerging workforce needs.

Engineering education scholars have a role in conducting and disseminating research on how we can broaden access to higher education and STEM fields, how we can create multiple pathways to STEM education, how we can provide outreach programs to the community, and how we can promote lifelong learning, to name a few. We hope you will join us: talk with your colleagues and your students to refine your ideas on what may be needed for the next Morrill Act; promote this concept with your university governmental affairs officers; and reach out directly to your local, state, and national elected officials. Encourage your university leadership and governmental affairs officers to promote this concept as part of the legislative agenda of the Association of Public and Land Grant Universities, which has a lead role in advocating on behalf of public research universities. The time is now to advocate for the next Morrill Act for the 21st century—to meet the challenges of the Digital Revolution and the Information Age, and to cultivate a student demand-driven approach to education and prepare citizens for the rapidly changing jobs of tomorrow.

ACKNOWLEDGMENTS

We framed the legislative proposal for the next Morrill Act for the 21st century during Camp Engineering Education AfterNext, a workshop aimed at promoting ideas and dialogue on educating the engineer of 2050 and beyond held at Purdue University in the summer of 2018. We thank Donna Riley and Leah Jamieson for convening, supporting, and helping advance ideas at Camp Engineering Education AfterNext. We also thank Li Tan for research support, Jenni Case and Howard Gobstein for valuable feedback on early versions of the paper, and the participants of Camp Engineering Education AfterNext for feedback and comments.

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