SCANNING OUR PAST

Setting the Standards for Engineering Education: A History

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Who controls engineering education? And how has this control evolved over time? While some folks may presume that ABET has undisputed control over engineering degree programs in the United States, those familiar with ABET Engineering Criterion 2000's origins know otherwise [1]. Moreover, history shows that the development of new standards in engineering education has always been a shared responsibility, with this responsibility being distributed in ways that reflect the broader fragmentation of the engineering profession. Still, the flurry of concern generated by ABET's proposed new accreditation standard suggests that issues of control, or governance, will remain a common feature within U.S. engineering education [2], [3]. As we converge around ABET's latest standard, we should use the broader lessons of history to understand how our recent conversations fit within a broader historical pattern, and use this to guide our future actions.

This month's article reviews the long history of efforts to define a proper standard for engineering education, and the implications this has for the current set of proposed changes to ABET's engineering accreditation criteria.

I. BACKGROUND

The systems of governance that exists for our educational systems have received wide scholarly attention. From debates surrounding access to public education [4], [5], to the expansion of federal responsibilities in higher education [6], and to national responses to perceived crises in science and engineering education [7], there is a long history of how our country reshaped its educational systems to serve the public interest. While this topic has also attracted the attention of those with an interest in social theory and critique [8], [9], this account focuses on the more conventional institutional politics that shape our system of engineering education.

Originally known as the mechanic arts, engineering has long been viewed as essential to our national interest. The land-grant institutions created under the Morrill Act of 1862 gave basic shape to the U.S. approach to engineering education [10]. But in keeping with the complex institutional makeup of our higher education system, regional developments in educational policy have also played a crucial role. For instance, the 1960 Master Plan for Higher Education in California, which was created during a period of expanding educational access and demographic growth, helped bolster the tri-partite system of higher education consisting of research universities, undergraduate institutions, and two-year colleges that remains the dominant pattern for higher education in the United States [11]. Still, unlike France, Germany, and the Scandinavian countries, where the engineering profession is more closely aligned with the state, U.S. engineering schools have also been shaped by regional industrial interests in ways that more directly amalgamate corporate, academic, and professional interests [12].

Historians have studied these institutional influences on U.S. engineering education. A key, early study, published in 1977, was David Noble's *America by Design* [13], which described engineering education as a system designed quite explicitly to serve American corporate interests. While adopting, in the end, a position not altogether different from Noble's, Edwin Layton found engineers to be situated in a more tenuous balance between professionalism and corporate interests [14]. Others subsequently challenged even further Noble's hegemonic view of the profession. For instance, by focusing on MIT's cooperative education program with General Electric, W. Bernard Carlson documented how during the 1900s–1920s one group of engineering educators exhibited more

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substantial autonomy, based on their assertion that engineering knowledge and research were not always simply aligned with corporate interests [15]. Others, most notably Kline [16], Reynolds, and Seely [17]–[21], have explored the different ways in which engineering schools, professional associations, and other organizations came to define the dominant directions in U.S. engineering education.

Taken together, these studies make it clear that the original Morrill Act was indeed instrumental in defining the basic structure for engineering education in the United States. While private engineering schools and technical institutes preceded this Act, this major government investment in public higher education rapidly expanded the U.S. capacity for engineering education and helped establish it on a four-year undergraduate model [17]. And despite the Morrill Act's emphasis on more practical education, the development of state colleges under a general university model ensured that liberal education occurred alongside technical training in engineering. This meant that, for a short while, engineering education had a curricular structure that was better defined than medicine: as contrasted against the high degree of variation still found in medical educational at the time of the Flexner Report (1910) [22], by the turn of the 20th century, private engineering colleges had already begun to emulate the basic curricular structure laid down by the state colleges. Stated more explicitly in terms of educational governance, it was not just a case of state intervention, but direct state investment in higher education that gave basic shape to the U.S. system of engineering education [10], [23].

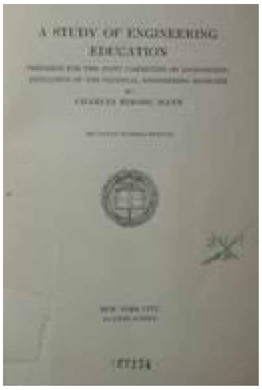
The other major consequence of the Morrill Act was that it created a group of educators whose professional identification, as educators, rivaled their professional disciplinary identities. Although U.S. medical schools continued to hire practicing physicians, the rapid expansion of U.S. engineering schools required that they hire full-time faculty. But because the engineering profession's division into disciplinary societies offered no common place for these educators to share their views about teaching, engineering became the first profession to create an academic society dedicated to its own system of training. The Society for the Promotion of Engineering Education (SPEE, predecessor to the American Society for Engineering Education) was established in 1893 during the World's Columbian Exposition in Chicago [17], [19], [23, p. 10].

Despite sharing a basic curricular structure, there remained nontrivial differences among U.S. engineering schools. Engineering schools were set up at public and private universities; as autonomous schools, as part of a general university, and as sometimes embedded within liberal arts colleges; and some operated as semiautonomous professional schools in a specific field, while others operated as a set of engineering departments within a unified school or college of engineering. In addition, each school operated with a unique mix of support from philanthropic institutions, regional industries, the dozens of separate state systems of higher education, and both direct and indirect support from the federal government. Schools like Worcester Polytechnic, Carnegie Institute of Technology, the Columbia and Colorado School of Mines, the Sheffield School and Sibley School at Yale and Cornell, and the many unnamed engineering programs at land-grant colleges exhibited differing commitments to theory versus practice, teaching versus research, and the value of breadth in technical education. In the United States, the invisible hand of the market operated alongside state investments and policy in the development and governance of the U.S. system of engineering education [23, p. 10].

II. EARLY REFORMS

The first concerted effort to bring greater order to engineering education occurred in 1907 under SPEE President Dugald Jackson. But as much as the move to bring more uniform standards to engineering education originated with the professional societies, their approach to reform was substantially influenced by another civil sector organization, The Carnegie Foundation for the Advancement of Teaching. As a philanthropic organization devoted to educational reform, the Foundation not only bankrolled SPEE's first (and second) study—and, incidentally, the Flexner Report—but it also gave the organization full knowledge of the Progressive Era's educational reform practices. The Foundation therefore insisted that SPEE hire an objective expert who stood at a proper distance between expert authority and disinterested inquiry, and taught them to employ survey methods and field work to gather the objective data necessary to support their findings. The underlying logic of SPEE's early studies was to amass best practices and to present them back to the membership as a means of establishing a regime of accountability [19].

The person chosen for this work, an "applied scientist" from the University of Chicago, Charles Riborg Mann, brought with him his own baggage. Though not unaligned with the interests of leading engineering educators, the report (Fig. 1) placed strong emphasis on science and fundamentals, and endorsed the parallel system of education for liberal and professional training



A STUDY OF ENGINEERING EDUCATION

Fig. 1. ***1918 Mann Report, Society for the Promotion of Engineering Education [24].***

that had already become reified within the U.S. approach to engineering education. Mann also expressed strong interest in new laboratory modes of instruction, as well as experiments in cooperative education [24].

The Mann Report was issued in 1918, but many felt that the chaos of World War I limited its impact. As such, SPEE proceeded to mount a larger investigation during the 1920s, this in an effort to enroll a much larger body of engineering educators into their ideas about reform. This time the study was carried out by William E. Wickenden (Fig. 2), who had been the head of recruitment and industrial education at AT&T, while "institutional committees" were set up at all participating schools both to collect data and to implement the study's recommendations [13, pp. 47–49], [19], [25].

The overall recommendations of the 1923–1929 Wickenden Investigations were quite similar to the earlier Mann Report [25]. It too emphasized, science, fundamentals, and breadth, as well as the parallel system of liberal and professional training that differed from the "sequential" model found in Law and Medicine. However, as the investigation drew to a close, Wickenden came to view the voluntary approach to compliance associated with such studies to be insufficient for thoroughgoing reform. He therefore began pushing engineering education in the direction of accreditation [19, p. 139].

Regional accreditation for U.S. colleges and universities began during the late 19th century, with the first systems for professional accreditation emerging during the 1910s [26]. Although state engineering licensing boards gave strong support to Wickenden's original proposal to conduct something like accreditation through SPEE, reservations inside SPEE prompted Wickenden to move beyond the organization. As such, a separate organization, the Engineers' Council for Professional Development (ECPD), was set up for this purpose [19, p. 139]. While ECPD originally had four functions consisting of student selection and guidance, professional training, professional recognition, and accreditation [27], the task of conducting accreditation reviews, as carried out by its Education Committee, came to dominate the Council's affairs.

Fig. 2. ***William E. Wickenden. (Source: Image #02109, Case Western Reserve University Archives.)***

Viewed in terms of governance, ECPD's formal structure continued to mirror the distributed structure of the engineering profession. Intentionally set up as a "conference-style" organization, ECPD was set up to have delegates from the six major "founder" societies, along with the National Council of State Boards of Engineering Examiners, and SPEE. Reflective of the divergent interests of the engineering professional societies, a basic decision was also made to accredit individual degree programs, not institutions. (This made sense at a time when more than one semi-autonomous engineering professional school could be affiliated with a single institution.) Moreover, for reasons that are less clear, ECPD allowed institutions to put forward any new engineering degree program for evaluation. This would come to include a wide array of emerging subdisciplines such as aeronautical engineering and agricultural engineering, but also degree programs in more specialized fields such as ceramic engineering, public health engineering, and fuel technology, in reflecting the continued influence of regional industries [19, p. 139], [27], [28].

III. WORLD WAR II AND THE COLD WAR

Further changes in governance occurred around World War II. Among these was the expanded administrative responsibility and authority granted to engineering deans, especially as a result of the war mobilization effort. The engineering deans played a prominent role in two more SPEE studies, one conducted on the eve of World War II, and the other produced in the context of postwar planning (Fig. 3). Both were headed up by Wickenden's former Associate Director of Investigation, Brooklyn Polytechnic, and later Penn State Dean of Engineering, Harry P. Hammond [29], [30]. While both reports,

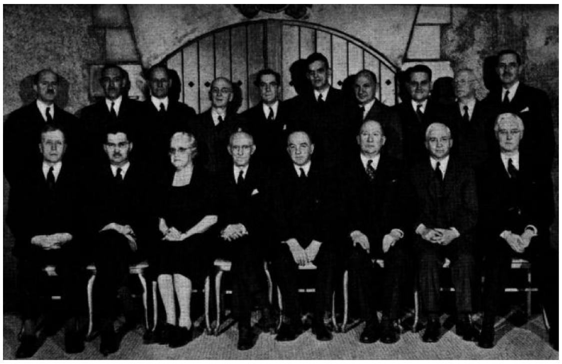


Fig. 3. ***Committee on Engineering Education After the War. (Source: Journal of Engineering Education, vol. 34, no. 9, p. 593, May 1944. Reprinted with permission of ASEE.)***

published, respectively, in 1940 and 1944, reiterated the basic recommendations of the earlier investigations, the second report also emphasized the benefits of more centralized administration [23].

The most important development in the postwar context was the sudden rise in federal research dollars, and the associated ascent of engineering science. While labeled a "catchphrase," engineering science nevertheless marked a broad shift toward a more science and research-based approach to engineering and engineering education. At the national level, the associated shift in curricula was driven by a pair of studies conducted by the American Society for Engineering Education (ASEE; succeeded SPEE in 1946), namely the 1955 Grinter Report [31] and 1968 Goals Report [32].

While both studies were nominally conducted by ASEE, the Grinter Report was basically commissioned by ECPD at a time when Cornell Dean of Engineering, Solomon Cady Hollister (Fig. 4), served as both the chair of ECPD's Education Committee and as President of ASEE. As chair of the Education Committee, Hollister indicated that he wished for there to be another general evaluation of engineering education, and as President of ASEE, he accepted this request by declaring 1951 a "Year of Evaluation" [33]. While the Committee on Evaluation of Engineering Education, conducted by University of Florida Graduate Dean, Linton E. Grinter, took four more years to complete its report, the report orchestrated a basic change in engineering curricula and accreditation [23, p. 17f], [34].

Up until the Grinter Report, engineering accreditation occurred along the same patterns that had governed the regional accreditation of universities, which was based primarily on qualitative guidelines. The initial move toward quantitative standards for accreditation occurred with the 1944 Hammond Report, which stipulated that 20% of an engineering student's coursework ought to be devoted to "humanistic-social" study [30]. This built on the engineering educators' continued commitment to liberal-professional education, their perceived need to reverse the shift to more narrow, accelerated training during the war, and the continued increase in the engineering dean's authority. It was during a key meeting between ASEE's Committee on Evaluation and ECPD representatives in December 1952 where the latter indicated they were willing to consider quantitative standards [35]. While the Grinter Report would prove controversial—it recommended a bifurcated system of accreditation along "professional-scientific" and "professional-general" lines that many immediately took to be a two-tier system of accreditation—the shift to quantitative standards, along with a heavier focus on science and fundamentals became the defining feature of accredited engineering curricula in the United States [19, p. 141f], [34], [36]; also [21], [23, p. 17f]. Citing the ASEE study, ECPD passed a set of uniform requirements that required all programs to provide one year of math and basic science; one year of engineering science; half a year of engineering analysis, design, and engineering systems; and a half a year to a year of study in the humanities and social sciences [37], [38].

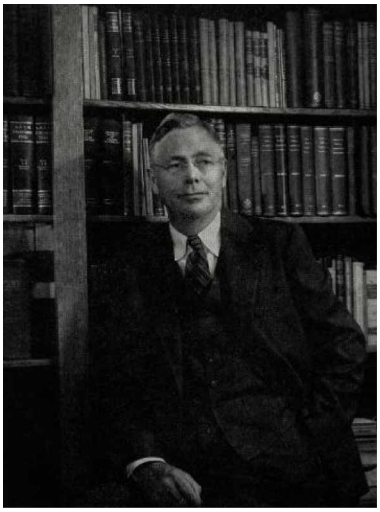


Fig. 4. *Solomon Cady Hollister, ASEE President, 1951–1952. (Source: Journal of Engineering Education, vol. 42, no. 1, p. 2. Reprinted with Permission of ASEE.)*

Despite beginning to act more independently, ECPD still regarded ASEE to represent the broad community of engineering educators who had the right and responsibility to determine the educational standards that ECPD would be called upon to enforce. This attitude carried forward to the next major investigation, the ASEE Goals Report, carried out by Penn State President and its former Dean of Engineering, Eric Walker. The Goals Report was a response to the Grinter Report. There remained broad criticism of Grinter's Report, including from Walker's own successor as engineering dean, that engineering students were being taught everything except how to be an engineer [39]. Indeed, under the new quantitative standards, the time that was nominally left for study within a specific engineering discipline, aside from the adaptation of content that occurred in the engineering science courses and courses devoted to engineering analysis, design, and systems, was but a half a year to a year of the student's degree program [19, pp. 142–144].

While the Goals Report could have chosen to simply rebalance the emphasis on theory versus practice, Walker, whose own commitments lay with engineering science, chose a different path. During the 1960s, every university administrator was grappling with the demographic changes associated with the baby boom. As a president of a sizable university system, Walker was swayed by a pair of influential studies that emerged out of California, the first being the 1960 California Master Plan, and the second being an Engineering Master Plan for the University of California system published five years later [11], [40], [41]. Using basically the same log-linear enrollment projections that were embedded in these reports, Walker's investigative teams produced linear projections of enrollment growth for bachelor's, master's, and Ph.D. degrees as based on national data, and this suggested that the master's degree would overtake the bachelor's degree as the dominant degree in engineering education (Fig. 5). This brought Walker to make the controversial recommendation that engineering educators should aspire to make the master's degree the first professional degree in engineering. The Goals Report would also recommend that this professional degree remain an undesignated degree, similar to the MBA [32], [42].

While echoes of this position still circulate today, most U.S. engineering schools remained firmly committed to a four-year undergraduate model. Students pursued engineering as a common pathway for upward social mobility, and given the Cold War labor market in technical fields, many chose to enter industrial employment immediately after college, even if they returned later to pursue a master's degree. While a number of institutions, including Cornell under Hollister, experimented with mandatory five-year programs [44], competition with other schools and the fiscal pressure of state budgets created the condition necessary to maintain the four-year undergraduate degree as the *de facto* professional degree in the United States—although technically, the undergraduate engineering degree, both then and now, was understood to provide only the basic preparation for professional practice, with professional recognition outside of Professional Engineer (PE) registration and licensure occurring through meritocratic standards set by individual firms and industries. Amidst the contraction in defense spending during the 1970s, and the fiscal struggles that many states faced during this period, the political limits of state support for higher education also became an ever spreading reality. While not every institution rejected the Goals Report, the report nevertheless uncovered significant rifts within the U.S. engineering education community, and crippled ASEE's ability to serve as the voice of engineering education [20, p. 145]; also [19, p. 145]; also [43] and [44].

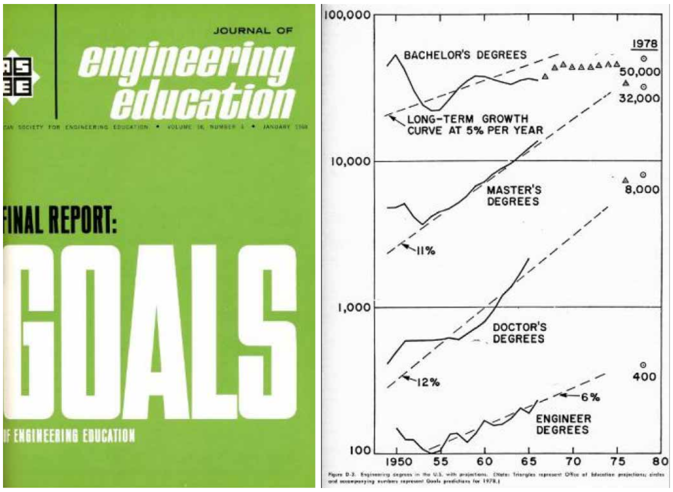


Fig. 5. ***Engineering degrees in the United States, with projections. (Source: 1968 Goals Report, Journal of Engineering Education, vol. 58, no. 5, p. 399 and cover page. Reprinted with permission of ASEE.)***

IV. ECONOMIC GLOBALIZATION AND EC 2000

Historical records are more limited from this point forward. Nevertheless, given the present conversations about the proposed changes in ABET's engineering accreditation standards, I will do what I can to bring the story up to the present.

While a number of studies were produced after the Goals Report, both by ASEE [44], [45] and other organizations [47], [48], it appears that ECPD began operating even more independently after the Goals Report. But while this might be seen as a continued shift in authority from ASEE to ECPD, a process that had already begun by the time of the Grinter Report, published accounts as well as anecdotal evidence suggest a somewhat more complicated picture.

ECPD became the Accreditation Board for Engineering Technology (ABET, Inc.) in 1980 to more properly reflect the scope of its major activities. While adequately managing the process of accreditation, as a policy generating body ABET was considered by many to be a weak organization prone to inaction and drift. As a consequence, elite engineering schools began speaking up against the relative inefficacy of accreditation in doing anything but maintaining minimum standards. Criticism was also directed at ABET's audit culture, or the "bean-counting" approach that resulted from their shift to quantitative standards. Many felt that quantitative standards prevented, and in fact frustrated educational innovation at institutions interested in exploring alternative approaches. Accreditation was also said to be meaningless for universities with strong academic programs, and a serious drain on the faculty's time [1], [48], [49].

What finally drove change was the rising tide of concern about national competitiveness. Given the growing U.S. trade imbalance, and what appeared to be the Japanese government's successful investments in state-supported commercial R&D, many felt that the United States needed to adopt a similar approach to industrial research. Drawing on broader historical currents having to do with the rise of neoliberalism—the extension of free market ideologies, especially into public sector activities—there was a concerted effort to transform federal agencies into more effective entities for supporting U.S. market institutions, including stronger partnerships in the area of research and technological innovation [50]-[52].

Still, when compared to their Japanese counterparts, U.S. governmental agencies continued to act independently instead of fully embracing the public-private partnerships that were a signature of many neoliberal reforms. One example was the National Science Foundation's decision to establish the Engineering Education Coalitions (EEC). Frustrated by the limits of what could be accomplished through small, individual research grants, but enamored by the newly sanctioned central planning model, NSF's Engineering Directorate proceeded to issue six, still-largely academic research grants at the level of $15 million apiece. Consistent with an NSF-wide shift toward more targeted research, these were multi-institutional grants designed to foster collaborative studies of engineering education in several well-defined areas, and they were accompanied by a strong mandate to both measure and disseminate research results [53].

Fig. 6. ***Joseph Bordogna, NSF Engineering Directorate. (Source: IEEE Engineering and Technology History Wiki, http://ethw.org/w/images/9/95/3197_-_bordogna.jpg.)***

While not entirely a failure, neither were the EECs a resounding success. Forced into an unfamiliar mode of collaboration, and asked to tackle some rather intractable problems whose root causes lay with the underlying structure of U.S. engineering education, much of the research monies became divided up into a familiar pattern of independent research that did not always produce integrated outcomes. While there were some enduring changes in areas such as a focus on foundations and design, the EECs were not able to radically transform the culture of engineering education [23, p. 26], [54], [55].

As a consequence, the new head of NSF's Engineering Directorate, Joseph Bordogna (Fig. 6), advanced a new vision under the slogan, "innovation through integration." This vision specifically targeted ABET's quantitative standards, which Bordogna and his colleagues claimed enabled faculty to teach in their respective areas without attention to a student's ability to retain, let alone utilize their knowledge. Arguing that further innovation in engineering education would not occur by trying to pack any more knowledge into a student's head, they called for more systematic changes that would allow students to develop a more robust and integrated knowledge of engineering that would enable them to make a meaningful contribution to the national economy [56].

The endpoint of this dialog was ABET's Engineering Criterion 2000. NSF was not the only entity to be concerned about ABET. Indeed, it appears that ABET was somewhat blindsided when a very broad coalition of engineering professional, industrial, and academic organizations made accreditation their object of scrutiny. Although NSF funded the stakeholder workshops that produced the principles—and stronger public–private partnership—behind EC 2000, these principles drew on the perspectives of university presidents, engineering deans, faculty members, industry leaders, executive directors of engineering professional organizations, and other public and private entities including ABET itself [57]. Paralleling the neoliberal turn in U.S. public K–12 education, and its shift in emphasis to learning outcomes, EC 2000 also embraced a learning outcomes and assessment model that replaced ABET's quantitative approach to accreditation [1, p. 168f], [58, p. 435].

The EC 2000 accreditation criteria themselves offer a direct window into the specific concerns that drove this reform initiative. Under Criterion 3, EC 2000 placed a definite emphasis on expanding professional skill sets: at least seven of the 11 original learning outcomes for engineering graduates were rooted significantly if not entirely in nontechnical skills such as teamwork, identifying and formulating problems, designing to meet client needs, professional and ethical responsibility, communication, an understanding of technological impacts, and a knowledge of contemporary issues. EC 2000 still allowed for degree-program specific criteria. Nevertheless, as consistent with an emphasis on science, fundamentals, and breadth that went back to the earliest SPEE study—and was a reality since the Grinter Report—specialization remained a secondary component to an engineer's education. As stated in Prados and Peterson's retrospective account of EC 2000, this emphasis on professional skill sets was what industry leaders were most concerned about, and found to be most deficient in U.S. engineering graduates [1]; see also [59]. Based on what were also, in effect, orientalized fears about a vast sea of engineers emerging out of Asia, EC 2000 was an attempt to create a unique profile for American engineers under the general rhetoric of economic competitiveness [60]; see also [61].

ASEE's Liberal Education Division was among those caught off guard by EC 2000. At yet another NSF sponsored workshop, members of ASEE's Liberal Education Division met to discuss the implications of EC 2000, yielding a series of reports [62]. Deciding that it was unlikely that many schools would devote more time to liberal subjects, the authors of the workshop's principal white paper did not recommend an expanded program in the humanities and social sciences. Rather, they returned to a familiar refrain in suggesting that the humanities and social science faculty and the engineering faculty had to work together to define a set of reasonable, institution-specific objectives consistent with the new criteria [63].

In seeking to foster educational innovation and differentiation, EC 2000 intentionally passed matters of implementation down to the local level. As the Liberal Education Division's leadership anticipated, EC 2000 did not, in fact, produce a general expansion in the time devoted to professional subjects, although some additional work, especially in writing and communication, is now happening within the disciplines. There is also now a more consistent emphasis on computer simulation, application exercises, case studies, open ended problems, design projects, and group work [59]. While the extent of the changes beyond this remains modest, one other impact of EC 2000 was that it empowered engineering faculty to nudge their colleagues in the humanities and social sciences toward—and in some cases actively embrace—a more instrumental attitude toward their subjects. There have, for instance, been various new initiatives to bring about greater integration between engineering and the liberal arts [64], [65]. On the other hand, universities with strong liberal arts faculties who need to attend to their own majors have been less likely to change. Even at engineering schools, the humanities and social sciences faculty often resisted the more instrumental approach to their subject mandated by EC 2000. This sometimes produced novel outcomes, such as the establishment of a campus-wide center for leadership training. There has been no systematic survey of the institutional responses to EC 2000, although a systematic survey of curricular changes designed to produce a shift in learning outcomes was conducted at Penn State as supported directly by ABET [1], [59].

V. RECENT DEVELOPMENTS

This brings us to the present situation. It is clear that the broad emphasis on professional training was difficult for many institutions, this as a result of resistance from liberal arts as well as engineering faculty. Being aware of these problems, ABET's Engineering Accreditation Commission (EAC), having overseen two full cycles of evaluation under EC 2000, initiated an internal review in 2009. They did so by creating a task force to review the student outcomes listed under Criterion 3. Publicly available documents indicate that EAC specifically charged this task force to develop a systematic process for assessing, evaluating, and recommending improvements to Criterion 3. They also instructed the task force to query constituencies, develop metrics for evaluating the criterion, and find a solution that would encourage educational innovation and greater differentiation across institutions [66], [67].

The Criterion 3 Task Force followed their charge, consulting with a number of different constituencies including the ABET Industry Advisory Council, a group instrumental to the original development of EC 2000. They also had the EAC conduct a survey of program evaluators, which identified a wide range of learning outcomes related to the broader professional skills that institutions seemed to have the most difficult time documenting or meeting. The task force also found institutions struggling to create innovative programs, and attributed the cause to what they felt was the still long list of learning outcomes that encouraged a return to the "bean counting" approach. Yet, at the same time, their conversations generated 75 suggestions for additional learning outcomes. Meanwhile, the interpretive flexibility granted by nonquantitative standards was producing inconsistent accreditation outcomes. From the task force's standpoint, it seemed a logical conclusion that eliminating the outcomes that programs were having the greatest difficulty meeting, and thus also reducing the total number of learning outcomes from 11 to six, would be the most efficient way to open up a space for educational innovation while also producing more consistent evaluation outcomes [66], [68].

This result is quite interesting from the point of view of organizational sociology. So long as EC 2000 was defined by a broad professional coalition that included a diverse array of public and private institutions, EC 2000 was an aspirational document defined by strong, professional objectives. However, when the learning outcomes were made the object of an internal review carried out by a task force two levels down, the focus shifted from professional interests toward operational issues having to do with things such as consistent evaluation outcomes, the capacity of ABET's volunteer program evaluators, and what the members of this task force honestly felt were realistic expectations that could be placed upon the programs undergoing evaluation.

Not surprisingly, when the task force's recommendations were passed back to EAC's Criteria Committee in 2014, and subject to a preliminary round of public comment, many of the constituencies who were not privy to the early conversations weighed in, and broader professional objectives were quickly reinserted into the list of student learning outcomes. Several of these, however, have been reintroduced as "combined" outcomes in an effort to still limit the total number of enumerated Criterion 3 outcomes to just seven, generating some debate as to what implications this has for program evaluation [3], [69]. Following the ABET Engineering Area Delegation's approval, these revised criteria were subject to an additional year of public comment, after which the Criteria Committee made further changes. The latest version of the proposed changes submitted by the EAC has again been approved by the Engineering Area Delegation for a new round of public comment, which remained open thru June of this year. The ASEE membership's discussions about the proposed changes may be found at https://aseetownhall.files.wordpress.com/2016/10/summary-of-asee-member-views-revised-final.pdf, while a side-by-side comparison of the current and proposed criteria may be found at http://www.abet.org/blog/news/proposed-eac-criteria-changes-released-for-public-review-and-comment/.

VI. HISTORICAL LESSONS

There continues to be some discussion about whether these changes represent a strengthening or weakening of engineering education. I specifically do not weigh in on this question in this essay, partly because my expertise rests with the past, not the present. However, it is also because I am a participant in this conversation. As the chair of an ASEE Ad Hoc Committee on Interdivisional Cooperation, it has been my goal to facilitate society-wide discussions about the proposed standard, but not to directly shape the outcome. My goal, in other words, has been to give the community of engineering educators some of the voice they lost with the decline in ASEE's investigative traditions.

Still, historical perspective can be useful for everyone, including those beyond ASEE, to understand the contexts within which we operate. This also provides a way to bring this article to a close. Even this encapsulated history should make it clear that the pattern of educational governance in engineering education has shifted considerably through time, and that these changes have nevertheless mirrored the distributed structure of the engineering profession. From the early, voluntary traditions of ASEE; to the more closed door deliberations of ABET; to a brief period of coordinated planning during the origins of EC 2000 amidst heightened concerns about national competitiveness; and then a return to internal deliberations within ABET—but as held in check by the system of accountability built into the representational structure of ABET—we have seen engineering educators repeatedly change their approach to how it makes key decisions. This account should also make it clear that governance is not just about which organization is in control, but the political and bureaucratic processes, both codified and improvised, that are built into the organizations that give different constituents a voice in shaping engineering education.

If engineering educators wish to get a better handle on how to best carry out conversations about new educational standards, it might be good to consider how these conversations take place in other domains. Two examples come to mind. One obvious point of comparison is the Liaison Committee on Medical Education (LCME). While LCME also operates on something like a delegate-based model, the stable structure of the medical profession, and a longstanding awareness of the need to regularly update medical curricula has given the LCME a more regular way to deal with conversations about a change in accreditation standards. If communication with the delegates or the delegates' capacity to represent the views of a member organization are an issue—as was suggested during the recent round of conversations about ABET—a study of how other organizations such as LCME works with its delegates might also be quite instructive [70].

A second point of comparison, and one quite different from the first, is the Bologna Process in Europe. As described by educational policy analyst Clifford Adelman in his report "The Bologna Process for U.S. Eyes" [71], Europe wound up embracing a very different approach for "harmonizing" its higher education system. Instead of going with an accreditation regime, Europe adopted a nominally uniform "3 + 2" model for higher education, built atop of EU free market principles and a commitment to workforce mobility that allows college students within a defined European Higher Education Area to transfer to a different school after their first three years of study. This was enabled by reworking a system designed to facilitate transfer credits [the European Credit Transfer System (ECTS)] into a more robust tool for quality assurance. While ECTS emphasizes instructional inputs over learning outcomes, it nevertheless goes further than accreditation in terms of creating a transparent measure of each institution's degree programs, student effort, and faculty investments in time. It has been a vehicle for mobilizing market mechanisms to remake Europe into a single, common market for higher education. Moreover, within peripheral countries of Europe—countries such as Ireland, Norway, Portugal, and Denmark—and institutions seeking to aggressively expand enrollments, the higher Candidate's degree, which students receive after the two additional years of study, are emerging as specialized degrees tagged explicitly to the needs of a high-tech, "innovation economy." Given the strength of Europe's secondary schools, many European universities are also banking on the claim that this higher degree is equivalent to the U.S. master's degree within the global marketplace for technical labor. This means that Europe may in fact be making the transition to the master's degree as the first professional degree in engineering in what has proven so elusive in the U.S. context. Should this be the case, these developments will surely overshadow the curricular changes that we are considering today [72], [73].

Engineering education reform has been a challenge in the United States because of the distributed structure of the engineering profession. But if Europe's education ministers can find common ground despite all their differences, surely engineering professional organizations can also find a way to coordinate their activities in this area. Such coordination is perhaps what is most needed for thoroughgoing educational reform. ■

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