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FOUNDATIONAL PERSPECTIVES ON ETHICS IN ENGINEERING ACCREDITATION

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This chapter takes a historical approach to examining and contextualizing the formal incorporation of ethics and related learning outcomes in accreditation criteria for engineering graduates. We begin by examining the origins of modern forms of accreditation in higher education, emphasizing key developments in the United States over more than a century. We also note more recent, widespread moves from inputs- to outputs-based frameworks (i.e., shifting focus from curricula and resources to graduates' capabilities), alternate quality assurance methods in some other contexts, and the continued global influence of American-style accreditation models. We then present a series of specific cases to explore when, where, and how ethics and associated concerns have been formally codified in accreditation requirements for engineering graduates. We begin by examining the United States as a particularly well-documented and influential example, followed by two other Western/Anglo settings (the United Kingdom and Canada). We then turn to two international agreements (the Washington Accord and EUR-ACE) and two East Asian cases (Japan and China).

One main goal of this chapter is to historicize attention to ethics in accreditation policies for higher engineering education. By doing so in a cross-national, comparative manner, we identify broader trends such as increasing attention in accreditation guidelines to an ever-wider range of concerns and considerations linked to engineering ethics, professional responsibility, and associated learning outcomes. Yet our efforts also begin to illustrate how local contextual factors (e.g., cultural, organizational, political) likely inflect accreditation criteria and processes, in turn hinting at reverse salients that counteract global convergence trends.

Our approach to developing this chapter involved synthesizing prior scholarship, including other secondary accounts, and performing new analyses of some primary source materials. We took a broad view of ethics when examining accreditation documents, and our choice of specific cases for this chapter was inflected by the authors' expertise, background, and positionality. All three of us hold undergraduate degrees in engineering and graduate degrees in the humanities and/or social sciences. Our team also includes individuals who are from or have lived in the United States, United Kingdom, and mainland China, and the authors have previously conducted other cross-national comparative studies related to engineering education and practice. While the scope of our inquiry is constrained by limitations such as the availability of source materials and our own expertise (language, etc.), we hope this chapter inspires future research efforts focused on other countries and regions.

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Accreditation in higher education: historical origins and US trends

Mechanisms for monitoring the quality and legitimacy of universities can, in part, be traced to the early history of higher education in Europe, from the Middle Ages onward. Historians point to various kinds of oversight, including internal self-governance by student and faculty guilds and external mechanisms such as the formal chartering of institutions by the crown, state, or church (Maassen, 1997; Van Vught & Westerheijden, 1994). Another type of quality assurance emerged much earlier in China, where the Imperial Examination system was used over many millennia to screen candidates for civil-service positions (e.g., Min & Xiuwen, 2001). Yet as Maassen argued, modern accreditation – typically characterized by a focus on quality control mechanisms and the formal recognition of degree programs or entire institutions – "has its roots in American higher education" (1997, p. 124).

Some important early developments in the United States occurred with the establishment of its first colleges. Nine such schools (the 'Colonial Colleges') were operating by the time of the American Revolution, with 'charters' for their establishment usually granted by colonial governors, colonial assemblies, or the British Crown (Stoeckel, 1958). The charters helped establish the legitimacy of these institutions, giving them the formal, legal right to own property and grant degrees. Additional oversight and governance structures started to emerge by the 1780s, such as through the formation of a board of regents in New York to "charter, endow, and control" museums and schools in the state, including colleges (Harcleroad, 1980, p. 15). Nonetheless, historians note that the regulation of US colleges was generally lax into the nineteenth century, even as institutions of widely varying type and quality proliferated (Brittingham, 2019).

In 1847, the first non-profit, voluntary educational association was established in the United States: the National Medical Association, later named the American Medical Association (AMA) (King, 1982). Its founding was partly linked to concerns about the quality of medical education. While initially not very successful in addressing that particular issue, the AMA's efforts to develop a 'Code of Medical Ethics' had lasting impacts (King, 1983). More general calls to regulate US higher education intensified in the latter part of the nineteenth century, especially as new schools proliferated. In response, the late 1800s saw the establishment of regional, non-governmental accreditation bodies, beginning with the New England Association of Schools and Colleges (NEASC) in 1885 (Brittingham, 2009, p. 14). Colleges and universities were members of these voluntary organizations, which were in turn mainly focused on determining "which institutions were legitimately colleges" (Brittingham, 2009, p. 14) and publishing lists of such schools (Harcleroad, 1980, pp. 21–22).

The twentieth century was marked by several trends relevant to this volume. First, new associations focused on specific disciplines and fields multiplied from the 1910s onward. This created a regulatory structure where overall evaluation of universities or colleges was often conducted by regional associations, while discipline-based organizations accredited specific programs. Additionally, key features now associated with the US accreditation model developed during the middle part of the century. Per Brittingham,

> Between 1950 and 1965, the regional accrediting organizations developed and adopted what are considered today's fundamentals in the accreditation process: a mission-based approach, standards, a self-study prepared by the institution, a visit by a team of peers who produced a report, and a decision by a commission overseeing a process of periodic review.
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> *(2009, pp. 14–15)*

Further, the federal government gradually assumed a larger role in higher education, including through new laws and regulations – many from the post-war period – restricting access to federal funding (and especially student aid) to institutions accredited by recognized non-profit associations.

Another development worth noting involves growing emphasis on *results* and *outcomes* in accreditation processes, particularly in relation to student learning. As Nodine (2016) argued, the basic principles of outcomes-based education (OBE) can be "traced back hundreds of years to craft guilds, apprenticeship training programs, technical training programs (in the military, etc.), and licensure programs (for doctors, lawyers, etc.) where established standards for competence and performance have been identified for specific jobs and roles" (p. 6). He noted the resonance between outcomes-based approaches and the concept of mastery-based learning beginning in the 1920s and a turn toward competency-based education (CBE) from the 1960s onward. Nodine observed three key shifts in this confluence of movements, namely moves toward identifying specific learning outcomes, establishing how to assess or measure those outcomes, and developing more flexible and personalized educational pathways (p. 6).

In summary, the US system of accreditation reflects the country's cultural values and styles of governance, including a 'triad' of federal, state, and non-governmental actors, with the latter especially critical for providing a "self-regulatory, peer review system" for higher education institutions and programs (Brittingham, 2009, p. 10). As Akera et al. summarized,

> the highly decentralized system of educational governance within the U.S., and the great diversity of schools that are both the product and reasons for this ecosystem, have given rise to an extremely heterogeneous system. In the United States, accreditation serves as one of the few central mechanisms for shaping learning; it carries the weight of the state to the extent that it contributes to job and federal loan availability as well as licensure in selected fields.
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> *(2019, p. 1)*

Such points are salient in relation to other concerns, including questions about the place of learning outcomes related to ethics in degree programs and the diffusion of American-style accreditation models to other countries.

Further, accreditation is one of many kinds of quality assurance (QA), and alternative approaches like "academic audit and inspection" are more prevalent in some settings (Brittingham, 2009, p. 17). Today, accreditation is often associated with defining features like systematic self-assessment, some kind of external review mechanism, and a forward-looking evaluation philosophy (e.g., as reflected in 'continuous improvement' models). Since at least the late twentieth century, rising accountability pressures in higher education in many parts of the world have been accompanied by more widespread implementation of accreditation systems, albeit with notable local variations (El-Khawas, 2007). The number of foreign universities and degree programs directly accredited by US-based or international organizations has also grown considerably, a trend which has, in turn, been critiqued as a new kind of 'academic colonialism' (Altbach, 2003). As Altbach argued, "American accreditation is designed for the realities of American higher education" and exporting that model could pressure foreign institutions to conform to "American patterns of curricular and academic organization" (p. 6) while disregarding local realities.

Accreditation and ethics in engineering education: detailed cases

We now focus on cases focused on specific countries and international agreements. We begin with three Western/Anglo examples (the United States, the United Kingdom, and Canada), followed by two international agreements (the Washington Accord and EUR-ACE) and two East Asian cases (Japan and China). Readers may also want to consult the appendix of this chapter, as it provides verbatim excerpts of ethics-related outcomes/attributes for many of the accreditation frameworks discussed below.

United States

Early efforts to formally evaluate engineering degree programs in the United States were led by the American Institute of Chemical Engineering's (AIChE) Committee on Chemical Engineering Education starting in 1922, followed by the publication of a list of recognized degree programs at 14 schools in 1925 (Prados, 2008, p. 2). Prados claimed that the subsequent Wickenden report on engineering education helped stimulate broader interest in a new national organization with a similar role across engineering fields. As Wickenden declared, "If protection of standards is needed, the accrediting of engineering schools by their own organization and the national professional societies will probably prove to be much more effective than accrediting by educational bodies of a more general character" (1934, p. 1082). An organization of this sort, the Engineers' Council for Professional Development (ECPD), was established in 1932 with seven professional societies as its founding members (Prados, 2008, p. 6). The organization started accrediting engineering degree programs from 1935–1936 onward (Prados, p. 6).

As Stephan documented, the original ECPD accreditation criteria – unchanged from 1933 to 1950 – offered "virtually no specification of minimum standards, except that all accredited programs had to lead to a degree" (2002, p. 11). Yet in 1955, a new set of 'Additional Criteria' mandated more specific curricular requirements in mathematics, basic science, engineering sciences, engineering analysis and design, and humanistic-social studies (Parker, 1961, p. 14). These were specified as the minimum number of years of study (or fraction thereof) in each designated area. The ASEE's *Summary of the Report on Evaluation of Engineering Education* ('Grinter Report'), published in 1955, reflected this period's shift toward a quantitative view of degree requirements: "The consideration of curricula cannot proceed wholly on a philosophical or qualitative basis but must eventually be approached quantitatively in semester hours or at least in terms of fractional percentages of the total program" (CEEE, 1994, p. 85). Yet these new guidelines did not explicitly refer to 'ethics.' The 1955 criteria, for example, noted very generally that a student's humanistic-social studies coursework "should be selected from fields such as history, economics, government, literature, sociology, philosophy, psychology, or fine arts" (Parker, 1961, p. 14). However, the "qualitative" portion of this same document did mention "safety to life and property" as a relevant consideration for engineers doing design work, alongside economic and functional concerns (Parker, p. 14).

By the early 1970s, the ECPD's curricular requirements for accredited engineering degree programs were only a page long. They called for "the equivalent of one-half year to one full year as the minimum content in the area of the humanities and social sciences" (ECPD, 1971, p. 65), but did not explicitly refer to ethics or related themes. Yet, as the length and specificity of the ABET accreditation guidelines steadily increased from the 1970s onward, ethics and associated concerns became more explicit. For example, revised criteria published in 1973 referred to "the extent to which the program develops an ability to apply pertinent knowledge to the practice of engineering in an effective and professional manner," including "development of a sensitivity to the socially related technical problems which confront the profession" (ECPD, 1973, p. 44). The aforementioned humanities and social sciences requirement was also revised to simply specify "one-half year" as the minimum, while clarifying that such coursework was important for "making the young engineer fully aware of his [*sic*] social responsibilities and better able to consider related factors in the decision-making process" (p. 45). In 1974, a new footnote also clarified the meaning of the ECPD's required one-half year of engineering design "in its broadest sense" noting that "sociological, economic, aesthetic, legal, ethical, etc. considerations can be included" (ECPD, 1974, p. 68). In 1975, this same language was moved from a footnote into the body of the guidelines (ECPD, 1975, p. 75). These appear to be the first direct mentions of ethics in ECPD's accreditation guidelines for engineering programs.

These criteria were relatively stable until 1979 when ethics became even more pronounced in the ECPD guidelines. More specifically, the statement "development of an understanding of the characteristics of the engineering profession and the ethics of engineering practice" was added to the overarching preamble statement introducing the general program guidelines (ECPD, 1979, p. 60). This objective was further underscored in a later passage:

> An understanding of the ethical, social, and economic considerations in engineering practice is essential for a successful engineering career. Coursework may be provided for this purpose, but as a minimum it should be the responsibility of the engineering faculty to infuse professional concepts into all engineering coursework.
>
> *(p. 61)*

As Stephan reported, the latter passage was retained for many years, "substantially unchanged until the issuance of EC 2000" (2002, p. 13).

Ethics and related concerns were also explicit in the general student outcomes presented as part of ABET's Engineering Criteria 2000 (EC2000) framework adopted in 1996 (Lattuca et al., 2006). The new guidelines stipulated that graduates should have "an understanding of professional and ethical responsibility" (Criterion 3.f), "the broad education necessary to understand the impact of engineering solutions in a global and societal context" (3.h), and "a knowledge of contemporary issues" (3.j) (Lattuca et al., pp. 18–19). The most recent version of the Criterion 3 outcomes includes expanded language around graduates having "an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors" (ABET, 2018, I.3.2). It also features a multifaceted outcome focused on ethics, namely: "an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts" (I.3.4). As reported by Matos et al. (2017), earlier drafts did not mention 'professional responsibility' in the ethics outcome, which generated considerable pushback and led to restoration of the phrase. Some of ABET's field-specific program criteria now also include attention to ethics and related concerns. For example, the criteria for "Civil and Similarly Named Engineering Programs" mandate coverage of "principles of sustainability in design" and the ability to "analyze issues in professional ethics" and "explain the importance of professional licensure" (ABET, 2018, III).

There are at least three key points to take from this brief account. First, explicit attention to ethics and related concepts was included in ABET guidelines earlier than previously reported. Both Pritchard (1990) and Stephan (2002) cited 1985 as the year when "understanding of the ethical characteristics of the engineering practice and profession" first appeared in the guidelines. Yet similar language initially surfaced in 1979, and other relevant statements and concepts appeared even earlier. Second, ABET EC2000 is often framed as a key point of transition where concerns over programmatic 'inputs' were replaced by a focus on 'outcomes' in engineering accreditation processes (Lucena et al., 2008). Yet the preceding account shows how ethics, professional responsibility, and related concerns were framed in outcomes-oriented language as early as the 1970s. This tracks well with other accounts regarding a gradual and more general turn toward outcomes- and competency-based approaches to education and training, especially from the 1960s onward (Hodge, 2007).

Finally, it is worth considering why the aforementioned changes were made. Unfortunately, the official accounts from ECPD offer little explanation. Period reports from the ECPD's ethics committee were primarily focused on a major revision of the ECPD Code of Ethics of Engineers, published in 1974 and then championed for more widespread adoption by other professional societies. Nonetheless, it is reasonable to speculate that the incorporation of ethics-related outcomes in the ECPD guidelines reflected broader movements, such as the efforts of engineer activists in the 1960s to critically interrogate the social and environmental effects of technology (Wisnioski, 2016), as well as the 1970s-era establishment of engineering ethics as a distinct scholarly field (Weil, 1984). More research is needed to establish whether and how these historical trends are connected. And, as Stephan (2002) pointed out, changing language in accreditation documents does not necessarily mean that engineering programs, or even accreditors, have historically treated ethics and related outcomes as key concerns.

United Kingdom

The United Kingdom was an important point of origin for engineering as a modern profession with roots going back to the eighteenth century. Yet fragmentation has been a hallmark of British engineering over this long history, in part reflected in the proliferation of engineering professional societies – and numerous calls to unify the profession (Klassen, 2018, pp. 78–84). As Klassen explained, accreditation of engineering programs in the United Kingdom has historically involved a complex assortment of policies and actors, including individual disciplinary professional societies, and with the Engineering Council providing additional coordination and oversight, especially from the 1980s onward. The United Kingdom's enduring tradition of apprenticeship-based training adds further complexity to this milieu.

Early efforts to unify the profession and improve coordination across the institutes are reflected in the creation of the Joint Council of Engineering Institutions in 1965 (called the Engineering Council since 1981) (Chapman & Levy, 2004). In 1984, the Council's *Standards and Routes to Registration* (SARTOR) established common training pathways and requirements for the three main professional grades recognized in the United Kingdom (Chartered Engineers, Incorporated Engineers, and Engineering Technicians). Second and third editions were published in 1990 and 1997. The latter (SARTOR3) is notable for specifying – like period documents from other countries – five specific outcome areas for each professional grade. One of these areas was specifically dedicated to "Professional Conduct" and declared that qualifying candidates for registration should "Make a personal commitment to live by the appropriate code of professional conduct, recognising obligations to society, the profession and the environment" (UKEC, 1998, p. 3), followed by four precepts that expanded on and clarified aspects of this general statement.

Concerns about the Engineering Council's influence over the accreditation of degree programs – including its efforts in SARTOR3 to raise standards – led to new reforms in the late 1990s and early 2000s. This included the promulgation of a new UK Standard for Professional Engineering Competence and Commitment (UK-SPEC) in 2003 to replace SARTOR. The new UK-SPEC placed greater emphasis on outcomes and eliminated earlier 'input-based' considerations like the quality of students entering degree programs (Temple, 2005). In 2004, the Engineering Council released its Accreditation of Higher Education Programmes (AHEP) policy and stated that it would share the responsibility for regulating engineering education standards with an independent non-profit, namely the Quality Assurance Agency for Higher Education (QAA) (EC, 2004). Additionally, the Engineering Council and Royal Academy of Engineering issued a common "Statement of Ethical Principles" for the engineering profession in 2005 (UKEC, 2017). As the most recent (4th) AHEP document notes, more than 40 engineering institutions are licensed by the Engineering Council to accredit degree programs in their respective fields (UKEC, 2020).

All four versions of the AHEP policy published to date include ethics requirements for engineers seeking registration at the incorporated and chartered levels. The first edition (AHEP1) stated that graduates should have an "Understanding of the need for a high level of professional and ethical conduct in engineering" and "Understanding of appropriate codes of practice and industry standards" and elsewhere repeatedly referred to the importance of health, safety, and risk issues, as well as environmental and sustainability concerns (UKEC, 2004, pp. 11–12). And although the next two editions (AHEP2 in 2013 and AHEP3 in 2014) showed little change in ethics-related outcomes, the most recent AHEP4 (released in 2020 and set to take effect in 2024) includes some notable revisions. First, it featured increasingly nuanced language to distinguish learning outcomes for incorporated and chartered grades, including for three distinct educational pathways associated with each. And while it retains five main outcome categories, it includes an "Engineering and society" category in place of "Economic, legal, social, ethical and environmental context" in AHEP3 (UKEC, 2014) and the even earlier "Economic, social and environmental context" in AHEP1 and AHEP2 (UKEC, 2004; UKEC, 2013). This category of outcomes also featured a revised preamble stating:

> Engineering activity can have a significant societal impact and engineers must operate in a responsible and ethical manner, recognise the importance of diversity, and help ensure that the benefits of innovation and progress are shared equitably and do not compromise the natural environment or deplete natural resources to the detriment of future generations.
>
> *(UKEC, 2020, p. 30)*

As this statement suggests, the new standard incorporates wide-ranging outcomes that refer to ethical conduct, risk management, sensitivity to the broader impacts of engineered solutions, and attention to diversity and equity concerns. Indeed, among educators interviewed by Xavier et al. (2023), "AHEP4 was believed to constitute a step change that encouraged the inclusion of [the] 'social'" (p. 4) in engineering programs.

As a final development worth noting, the Engineering Professors' Council (EPC) and Royal Academy of Engineering released an Engineering Ethics toolkit in 2021 "to help engineering educators integrate ethics content into their teaching" (EPC, 2022). As background, they note "growing advocacy for bringing engineering ethics to the fore in engineering programmes – alongside technical skills," including as reflected in current AHEP and UK-SPEC standards.

Canada

Since the early decades of the twentieth century, engineering has been legally regulated as a profession in Canada, mainly at the provincial/territorial level but with national co-ordination (Klassen, 2018, pp. 33–34). Oversight of engineering degree programs originated with establishment of the Canadian Accreditation Board (CAB) in 1965 as a standing committee of the Canadian Council of Professional Engineers (or Engineers Canada from 2007 onward), with the first assessments of undergraduate degree programs occurring in 1969 (CAB, 1975, p. 4). By 1975, the CAB's accreditation criteria specified required program content in five main areas, including "a minimum of one-half year of appropriate humanities and social sciences" (CAB, 1975, p. 15). While this document did not explicitly mention ethics, it did note the need for students to develop "social consciousness" and receive a "sufficient liberal education" (p. 12).

In 1976, a revised set of "specific objectives" included a section (B-1.7) stating that "Students must be made aware of the vital role of the professional engineer in society and the interaction of engineering work with the economic, social and human goals of the nation" (CAB, 1976, p. 10). The document went on to explain that students in accredited programs must understand:

a) the quality of the natural and human environment and the impact of technology;
b) the function and activities of our society, business and government in shaping our society and its values;
c) the legal responsibilities and ethical guidelines and constraints applied to the profession.

(CAB, 1976, p. 10)

As the report emphasized, "Every opportunity should be seized to weave into the fabric of engineering education an awareness of such matters through course material and through liaison with practicing engineers and other groups outside of the educational establishments" (p. 10). Another stipulation regarding a "minimum one half year of appropriate humanities, social sciences and administrative studies" clarified that the aim of such coursework was to "develop a social awareness as related to the philosophy of section B-1.7" (p. 14).

Similar language was retained until 1986 (under the renamed Canadian Engineering Accreditation Board, or CEAB), when a streamlined version of the accreditation criteria removed any direct mention of ethics. A new section of the guidelines (2.1.4) instead simply stated: "The criteria are intended to ensure that students are made aware of the role of the professional engineer in society and the impact that engineering in all its forms makes on the environmental, economic, social and cultural aspirations of society" (CEAB, 1987, p. 14). In the CEAB's 1989–1990 annual report, this statement was revised to refer to the "role *and responsibilities* [emphasis added] of the professional engineer" (CEAB, 1990, p. 14). Requirements published in 1993 also added language in the "Engineering Design" area to acknowledge "constraints which may be governed by standards or legislation to varying degrees depending upon the discipline. These constraints may relate to economic, health, safety, environmental, social or other pertinent factors" (CEAB, 1993, p. 17). In 1996, a new criterion was added (2.2.8) stipulating that "Each program must ensure that students are made aware of the role and responsibilities of the professional engineer in society. Appropriate exposure to ethics, equity, public and worker safety and health considerations and concepts of sustainable development and environmental stewardship must be an integral component of the engineering curriculum" (CEAB, 1996, p. 14).

The preceding language was retained verbatim until 2008 when it was replaced by a new set of 12 "Graduate Attributes" (CEAB, 2008, pp. 12–13). Four of the attributes refer to ethics or related concerns, namely (1) design, (2) professionalism, (3) impact of engineering on society and the environment, and (4) ethics and equity. This same document also retained quantitative requirements for curricular coverage in specific areas, including a stated expectation that all programs include studies of "The impact of technology on society," "Health and safety," "Professional ethics, equity and law," and "Sustainable development and environmental stewardship" (CEAB, 2008, p. 18). These requirements were subjected to only minor editorial changes in more recent versions of the CEAB guidelines. As this overview suggests, the current CEAB framework includes a fairly comprehensive set of ethics-related attributes similar to what can be found in policy documents promulgated in many other contexts.

Washington Accord

Western nations have had deep and lasting impacts on engineering education and professional practice around the world, both through colonial legacies and other influences. As a more specific example, the US-based ABET describes how it engages globally through four mechanisms: "1) accreditation of academic programs; 2) mutual recognition of accreditation organizations; 3) Memoranda of Understanding with accreditation/quality assurance organizations; and 4) engagement in global STEM education organizations" (ABET, n.d.). The third mechanism (regarding MOUs) includes specific cross-national agreements (e.g., between the United States and Canada concerning the accreditation of engineering degree programs, first signed in 1979) and more general agreements like the Washington Accord.

The latter is a multilateral framework that sets standards for mutual recognition of engineering degree programs and professional mobility among signatories, including six countries when initially signed in 1989 (Australia, Canada, Ireland, New Zealand, the United States, and the United Kingdom). Founded in 2007, the associated International Engineering Alliance (IEA) is a global non-profit organization that manages seven such agreements among members representing 41 jurisdictions in 29 countries (IEA, 2015). The IEA also maintains a set of "Graduate Attributes and Competency Profiles" developed from 2001 to 2005 by signatories of the Washington Accord (the preceding six countries, plus Hong Kong and South Africa). "Ethics" was one of 13 attributes in Version 1.1 of this framework ("Understand and commit to professional ethics, responsibilities, and norms of engineering practice"), along with other relevant concerns listed under "The Engineer and Society" and "Environment and Sustainability" (ABET, 2006). Similar categories and language were retained in later revisions (e.g., see IEA, 2013). Today, the Washington Accord has 23 full signatories and seven provisional ones (IEA, n.d.). As this overview suggests, a relatively small group of actors – primarily representing Western, anglophone nations or former colonies thereof – have spearheaded the development of global standards for accrediting engineering programs using outcomes-based approaches. As discussed in more detail below, Japan and China are contrasting examples of Washington Accord adoption, each likely inflected by distinct cultural and ideological factors.

European Accredited Engineer (EUR-ACE)

Beginning in the late 1990s, the intergovernmental initiative known as the 'Bologna Declaration' stimulated efforts to harmonize higher education programs across Europe (Augusti, 2007). Field-specific initiatives like the EUR-ACE (European Accredited Engineer) standard grew out of this larger trend. They became linked to a desire to increase the global mobility of engineering graduates, establish minimum quality standards for engineering degree programs, and encourage quality improvements (Augusti, 2007; Sánchez-Chaparro et al., 2022). EUR-ACE is a comprehensive standard with multifaceted attention to physical facilities; staff qualifications; program management; teaching, learning, and assessment practices; and so on (ENAEE, 2021).

Like other contemporary frameworks, EUR-ACE, from the beginning, also emphasized programmatic aims and student learning outcomes. Regarding the initial development of EUR-ACE, Augusti (2010) noted that a study of engineering accreditation systems across Europe "revealed striking similarities behind different façades" which in turn made "compilation of a set of shared accreditation standards and procedures comparatively easy" (p. 2). The resulting outcomes for EUR-ACE were organized around six core dimensions, with the sixth ("Transferable Skills") stressing the importance of graduates committing to "professional ethics, responsibilities and norms of engineering practice" (Augusti, Birch, & Payzin, 2011). The framework also underscored the importance of societal, environmental, ethical, and other "non-technical" considerations in three other outcome areas. Similar language and outcomes have been retained in more recent versions of the EUR-ACE standard (e.g., ENAEE, 2021).

From its 2006 inception to the present, the EUR-ACE designation has been granted to more than 4,000 degree programs at more than 700 higher education institutions in 46 countries, in Europe and beyond (ENAEE, n.d.). As EUR-ACE continues to spread, commentators have pointed out that the complexity and diversity of European higher education institutions and policy bodies introduce both benefits and challenges for cross-border quality assurance and accreditation efforts. For example, Sánchez-Chaparro et al. noted “difficulties in interpretation and consistency” of the European standards, while at the same time opening up “learning opportunities” as accreditation agencies work to adopt common standards while respecting cross-national contextual differences (2022, p. 322). How ethics is specifically treated in such processes is beyond the scope of this chapter, but worthy of further exploration.

Japan

Engineering as a modern field of practice originated in Japan in the late nineteenth and early twentieth centuries. Over time, engineers were primarily identified as members of corporate ‘households’ aligned with broader national goals for economic and technological development (Downey et al., 2007). Thus, the Western concept of autonomous professionalism is relatively new for Japanese engineers, and engineering societies in Japan have historically not operated like their Western counterparts, instead mainly focusing on creating standards for education and industrial practices. Indeed, most have had little historical engagement with codes of ethics or accreditation-related activities. Downey et al. reported that the Japanese Society of Civil Engineers has had a statement of “Beliefs and Principles of Practice for Civil Engineers” since at least 1938 but argued that it was “of relatively little consequence” (2007, p. 480). Another notable exception is the Japan Consulting Engineer Association’s (JCEA) first ethics codes (published in 1951 and 1961), which reflected influences from counterpart American societies (Kenichi, 2021). Kenichi additionally reports that Kimura Hisao, Chair of the IEEE Computer Society’s Japan Chapter, advocated for developing ethics codes among Japanese engineering societies in the 1960s and 1970s. Yet others expressed reluctance, arguing that (1) codes of ethics might encourage engineers to demand their own rights to the detriment of their social responsibilities and (2) it was unnecessary to develop codes of ethics for individual fields when there should be a code of ethics for *all* professional societies (Kenichi, 2021). Some IEEE Japan board members were also worried that establishing a code of ethics for a particular association (e.g., IEEE Japan) might be a selfish act, disturbing the harmony of the scientific community in Japan (Kenichi, 2021).

In the 1990s, the Japanese government undertook initiatives to internationalize engineering education programs and qualifications with the goal of making their engineers more globally competitive, in turn setting in motion a burgeoning professionalization movement. Engineering societies also started to establish their own ethics codes (Kenichi, 2021), and in 2000 the Japanese *diet* (legislature) passed an updated Professional Engineers Law, which explicitly referred to the ethical duties of engineers (Downey et al., 2007). Another key development involved the 1999 founding of the Japan Accreditation Board of Engineering Education (JABEE), which created an accreditation system similar to the US model. And in 2002, an ethics outcome was added to Japan’s accreditation criteria, stipulating that graduates of accredited programs should demonstrate “understanding of … engineers’ social responsibilities (engineering ethics)” (Downey et al., 2007). Yet early efforts to develop and roll out accreditation criteria came with growing recognition that there was a lack of ethics education in Japanese engineering education and uncertainty about how it should be taught (Iseda, 2008; Kanemitsu, 2021). Nonetheless, Sato and Harada (2005) found that 76.1% of surveyed institutions were soon thereafter offering courses in engineering ethics.

During this same period, the Japanese Society for Engineering Education (JSEE) established a committee to study the syllabi of engineering ethics courses in Japan and found that they incorporated some core ideas and key concepts from Western engineering ethics, such as the analogy between ethical problem-solving and design thinking and specific tools for ethical decision-making (Kobayashi & Fudano, 2004). The JSEE's Engineering Ethics Research Committee also assumed an instrumental role in providing nationwide guidance and resources related to engineering ethics education. Since 2012, this committee has developed three versions of the "Learning and Educational Objectives of Engineering Ethics Education." The most recent version features four learning objectives: (1) understanding the relationship between science, technology, society, and the environment (cognitive domain); (2) understanding the role, responsibilities, and duties of engineers (cognitive domain); (3) ethical judgment abilities and problem-solving abilities (cognitive domain); and (4) attitudes and shared values as professional engineers (affective domain) (Kobayashi & Fudano, 2016). These are in general alignment with current JABEE requirements, with one of the nine learning criteria focused specifically on "understanding of effects and impact of professional activities on society and nature, and of professionals' social responsibility." This criterion is in turn elaborated with a series of more specific statements:

- "Understanding of impact of technology of related engineering fields on public welfare"
- "Understanding of implication of technology of related engineering fields on environmental safety and sustainable development of society"
- "Understanding of engineering ethics"
- "An ability to take action based on the understanding mentioned above" (JABEE, 2016, p. 4).

Additionally, a dedicated design criterion specifies that graduates should be able to "specify constraints from public welfare, environmental safety, and economy" (JABEE, 2016). Such statements reflect a fairly typical range of concerns found in many accreditation frameworks. (For more on Japan, see Chapter 33.)

China (mainland)

Contemporary concerns about quality assurance in Chinese higher education must be situated against a much longer historical legacy and backdrop, including the civil-service examination system in Imperial China, which serves as one of the very first examples of a standardized test system (O'Sullivan & Cheng, 2022). This system ensured that students met the criteria (or 'learning outcomes,' in a modern sense) for professional politicians and bureaucrats serving the Imperial government – some of whom later became what we would now call engineers (Dodgen, 2001). The state employed various efforts and tactics to indoctrinate examinees, including through government-issued textbooks and the contents of the exam itself (Lin, 2021).

In more contemporary terms, developing countries such as China have often taken a pragmatic approach to developing professional standards and accreditation systems. This can take the form of borrowing from the West, as reflected in a series of ethics codes published from 1933 onward by the Chinese Institute of Engineers (CIE) (Zhang & Davis, 2018). As Zhang and Davis (2018) argue, the adaptation and evolution of these early codes seemed to reflect practical realities and national development objectives rather than Confucian cultural values. They and others (e.g., Cao,

2015) have additionally noted a lack of formal ethical codes for engineers in mainland China from the Communist Revolution (which ended in 1949) to the present. Yet this is not surprising given China's ideological context, that is, where Western ideas of autonomous, independent professionalism stand in tension with Communist party authority and values.

Nonetheless, ethics and related concepts have recently surfaced in engineering education, particularly against the backdrop of a pragmatic approach to accreditation policy-making. Given the lack of a pre-existing accreditation model, the Washington Accord was used as an actionable 'startup template' in China, but without fully acknowledging or challenging its fundamental ideas, concepts, and assumptions (Zhu, Jesiek, & Yuan, 2014). Chinese policy-makers made adjustments to the ABET accreditation process to ensure that the resulting policies were better aligned with China's unique cultural and political context (e.g., by seeing ethics and ideological education as related or interchangeable). Accreditation expert and former university administrator Li (2017) observed that the adoption of the Washington Accord accreditation criteria in the early development of China's engineering accreditation system served the pragmatic goal of ensuring that the professional qualifications of Chinese students who graduate from accredited programs would be recognized by other Washington Accord signatories – thus enabling global mobility of Chinese talent.

In 2013, China became a provisional member of the Washington Accord, and in 2016 a full signatory member. Scholars have argued that a major motivation for establishing an accreditation system for engineering education was in part linked to concerns over academic quality and administration (Wang, Zhao & Lei, 2014). Wang et al. also pointed out that, in contrast to other countries, China's accreditation system exhibited more 'top-down' characteristics. Rather than primarily relying on representatives from industry to shape the standards for accreditation, the central government spearheaded coordination and policy-making, including organizing expert panels for formulating learning outcomes for engineering programs.

Current Chinese accreditation standards include ethics-related statements in four different outcome categories, namely (c) Design/Development Solutions, (f) Engineering and Society, (g) Environment and Sustainable Development, and (h) Professional Ethics. Notably, the only direct mention of social responsibility in engineering is in outcome (h), which states that students who graduate from accredited programs should "possess literacy in humanities and social sciences and social responsibility," be able to "understand and comply with professional morality and norms in engineering practice," and "exercise [their] responsibilities" (CEEAA, 2022a, section 4.3). Like many other accreditation policies, the other learning outcomes noted here (i.e., (c), (f), and (g)) variously indicate that engineering practice – including design, analysis, and problem-solving activities – should include attention to social, environmental, health, legal, and cultural, and other impacts.

Nevertheless, Li (2017) reminded engineering educators in China that accreditation criteria should not be considered equivalent to engineering program quality standards. In other words, the accreditation standards are a minimum benchmark, and the ethics-related learning outcomes may not wholly satisfy the government's expectations regarding graduate engineers' ethical and political qualities. For instance, some moral and ideological educational goals set by the central government – such as cultivating the builders and successors of Socialism with comprehensive development in morality, intelligence, physical fitness, and aesthetic appreciation – are not explicit in the accreditation policies but are nonetheless central to the training of Chinese engineers.

Given the top-down governance structure of China's policy-making, China has also employed multiple tactics to ensure that engineering programs and accreditation experts accurately interpret the accreditation criteria set by the central government and incorporate them into educational reforms and program evaluations. To begin, the government implemented several 'innovative' organizational structures to purportedly guarantee the 'autonomy' of accreditation activities while also maintaining the central government's influence in accreditation practices. It designated the Chinese Association for Science and Technology (CAST) as the official agency responsible for representing China's membership within the Washington Accord. The major accreditation body, the Chinese Engineering Education Accreditation Association (CEEAA), then became a corporate member of CAST, despite the fact that CEEAA was initiated by and located in the Chinese Ministry of Education. As "the largest national non-governmental organization of scientific and technological workers in China," CAST oversees other engineering societies such as the China Civil Engineering Society. Additionally, these societies were granted the authority to offer expert guidance and direction concerning engineering accreditation within their respective fields of expertise. Therefore, one notable aspect of engineering ethics education in China is that engineering societies organize nationwide professional development activities that train faculty in their specific engineering fields to teach discipline-based engineering ethics (e.g., civil engineering ethics, safety engineering ethics, etc.).

From as early as 2016, the central government has also regularly published guidelines on how to interpret and implement the accreditation criteria appropriately. The Chinese Engineering Accreditation Association (CEEAA) published the two most recent guidelines in 2020 and 2022. These guidelines provide details on how each learning outcome should be evaluated and how to understand certain key terms such as 'ethics' and 'social responsibility' in students' learning outcomes. In the most recent revision, one of the six major guiding principles is related to the cultivation of responsible engineers:

> To further clarify the requirements for implementing the fundamental task of "cultivating moral character and nurturing talented individuals," it is demanded that the educational objectives of professional training reflect the education policy of fostering socialist constructors and successors who possess comprehensive development in morality, intelligence, physical fitness, aesthetics, and labor. The graduation requirements should also incorporate relevant content regarding socialist core values.
>
> *(CEEAA, 2022b, pp. 5–6)*

As this statement suggests, the pragmatic adaptation of Western professional standards and processes in the Chinese context reflects a core concern with positioning ideological allegiance to the Chinese Communist Party (CCP) above other types of ethical commitments and values.

Discussion and conclusion

As documented in this chapter, modern forms of accreditation in higher education have strong historical roots in the US system of higher education. The first formal mechanisms to accredit engineering degree programs also originated in the United States, evolving considerably over a century-long period and ultimately having a marked global influence. However, explicit attention to ethics and related concerns in accreditation requirements is a more recent trend. For the countries examined in this chapter, such statements first appeared in 1970s-era policies in the United States and Canada. These same guidelines additionally reflected the early presence and influence of outcomes-based educational philosophies, albeit in tandem with period expectations for content and curricula as 'inputs' for engineering degree programs seeking accreditation. A more widespread transition to outcomes-based standards for engineering education occurred from the 1990s onward, accompanied by growing attention to ethics and related concerns.

Further, the preceding account suggests considerable convergence toward a common, core set of ethics-related outcomes in accreditation frameworks in many different countries and regions. Such documents most often refer to (1) professional/ethical responsibilities in general; (2) ethics as an 'upstream' constraint or consideration in problem solving, design, and so on; and (3) the 'downstream' impacts of engineered solutions on society. Further, most accreditation policies now mention environmental and/or sustainability concerns, in some cases as dedicated learning outcomes. Interestingly, the scope of ethics-related outcomes in the two global policies introduced above (Washington Accord and EUR-ACE) essentially cover this outcome space.

It is worth pondering whether and how a kind of global 'standard' for accreditation has been developed and advanced in recent decades, in part linked to broader processes of globalization. Yet our analysis suggests notable points of difference and divergence. For example, we observe the somewhat recent appearance of diversity and equity considerations in some accreditation criteria, such as Canadian policies that jointly refer to 'ethics and equity.'

It remains to be seen whether similar statements start to appear in other accreditation frameworks. We also find that explicit mention of ethical codes of conduct or practice only appears in general accreditation guidelines from the United Kingdom, even though such codes are well established in many other countries discussed above. Further, our analysis suggests important contextual nuances in two East Asian settings. The overarching storyline in Japan seems most significantly inflected by local cultural values (e.g., collectivistic ways of being, promoting social harmony) and particular understandings of how Japanese engineers contribute to national progress. The Chinese case is likely also shaped by similar cultural values, but with political and ideological forces at the forefront, especially in terms of ensuring that the ethical and social responsibilities of engineers align with party values and priorities.

There were, of course, practical limits to the breadth and depth of analysis we were able to present here, and we acknowledge a growing body of scholarship exploring engineering accreditation histories and trends in other contexts, developed and developing countries alike. We hope our efforts inspire more cross-national comparative research, and indeed highlight emerging opportunities for bringing more ethics-related outcomes into accreditation guidelines worldwide.

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Appendix. Ethics-related outcomes/attributes from select accreditation frameworks

ABET - EC2000 (Lattuca et al., 2006)	**ABET - Current** (ABET, 2018)	**UK - SARTOR3** (UKEC, 1998, p. 3)	**AHEP1** (UKEC, 2004, pp. 11–12) (same for IEng and CEng programmes)
Outcome 3.f; "an understanding of professional and ethical responsibility" Outcome 3.h; "the broad education necessary to understand the impact of engineering solutions in a global and societal context" Outcome 3.j; "a knowledge of contemporary issues"	Outcome 3.2; "an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors." Outcome 3.4; "an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts."	"E. Make a personal commitment to live by the appropriate code of professional conduct, recognising obligations to society, the they must: E.1 comply with the Codes and Rules of Conduct; E.2 manage and apply safe systems of work; E.3 undertake their engineering work in compliance with the Codes of Practice on Risk and the Environment; E.4 carry out the continuing professional development necessary to ensure competence in their areas of future intended practice."	*Design;* "[I]dentify constraints including environmental and sustainability limitations, health and safety and risk assessment issues" *Economic, social and environmental context*; "Understanding of the requirement for engineering activities to promote sustainable development"; "Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues"; "Understanding of the need for a high level of professional and ethical conduct in engineering" *Engineering Practice*; "Understanding of appropriate codes of practice and industry standards"

AHEP4 - Current *(UKEC, 2020)*	**Canadian Accreditation Board (CAB) - 1976** *(CAB, 1976, p. 10)*	**Canadian Engineering Accreditation Board (CEAB) - 2008** *(CAB, 2008, p. 13)*	**Washington Accord - Version 1.1** *(ABET, Inc., 2006, p. 13)*
Design and Innovation: B5. "Design solutions for [IEng: broadly-defined; CEng: complex] problems that meet a combination of societal, user, business and customer needs as appropriate. This will involve consideration of applicable health and safety, diversity, inclusion, cultural, societal, environmental and commercial matters, codes of practice and industry standards." *The engineer and society:* B7. "Evaluate the environmental and societal impact of solutions to [IEng: broadly-defined; CEng: complex] problems."; B8. "Identify and analyse ethical concerns and make reasoned ethical choices informed by professional codes of conduct."; B9. "Use a risk management process to identify, evaluate and mitigate risks (the effects of uncertainty) associated with a particular project or activity." (IEng); "B11. Recognise the responsibilities, benefits and importance of supporting equality, diversity and inclusion." (CEng); "C11. Adopt an inclusive approach to engineering practice and recognise the responsibilities, benefits and importance of supporting equality, diversity and inclusion."	B-1.7. "An understanding must be acquired of: a) the quality of the natural and human environment and the impact of technology; b) the function and activities of our society, business and government in shaping our society and its values; c) the legal responsibilities and ethical guidelines and constraints applied to the profession."	3.1.4. "Design: An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, economic, environmental, cultural and societal considerations." 3.1.8. "Professionalism: An understanding of the roles and responsibilities of the professional engineer in society, especially the primary role of protection of the public and the public interest." 3.1.9. "Impact of engineering on society and the environment: An ability to analyse social and environmental aspects of engineering activities. Such abilities include an understanding of the interactions that engineering has with the economic, social, health, safety, legal, and cultural aspects of society; the uncertainties in the prediction of such interactions; and the concepts of sustainable design and development and environmental stewardship." 3.1.10. "Ethics and equity: An ability to apply professional ethics, accountability, and equity."	Attribute 9. *The Engineer and Society*, "Demonstrate understanding of the societal, health, safety, legal, and cultural issues and the consequential responsibilities relevant to engineering practice." Attribute 10. *Ethics*, "Understand and commit to professional ethics, responsibilities, and norms of engineering practice." Attribute 11. *Environment and Sustainability*, "Understand the impact of engineering solutions within a societal context, and demonstrate knowledge of and need for sustainable development."

EUR-ACE - 2008 *(Augusti, Birch, & Payzin, 2011, pp. 7–9)*	**Japan Accreditation Board of Engineering Education - Current** *(JABEE, 2016)*	**China Engineering Education Accreditation Criteria (CEEAA) - Current** *(CEEAA, 2022a)*
Outcome 2. Engineering Analysis, "Graduates should be able to … recognise the importance of societal, health and safety, environmental and commercial constraints." Outcome 3. Engineering Design, "[A] n awareness of societal, health and safety, environmental and commercial considerations." Outcome 5. Engineering Practice, "They should also recognise the wider, non-technical implications of engineering practice, ethical, environmental, commercial and industrial." Outcome 6. Transferable Skills, "[D]emonstrate awareness of the health, safety and legal issues and responsibilities of engineering practice, the impact of engineering solutions in a societal and environmental context, and commit to professional ethics, responsibilities and norms of engineering practice."	Criterion 1(2)(b), "An ability of understanding of effects and impact of professional activities on society and nature, and of professionals' social responsibility" • "Understanding of impact of technology of related engineering fields on public welfare" • "Understanding of implication of technology of related engineering fields on environmental safety and sustainable development of society" • "Understanding of engineering ethics" • "An ability to take action based on the understanding mentioned above" Criterion 1(2)(e), "Design ability to respond to requirements of the society by utilizing various sciences, technologies and information" (including) "An ability to specify constraints from public welfare, environmental safety, and economy to be taking account of"	c) Design/Development Solutions: "Able to design solutions for complex engineering problems, design systems, units (components), or process flows that meet specific requirements, and demonstrate innovative thinking during the design phase while considering social, health, safety, legal, cultural, and environmental factors." f) Engineering and Society: "Able to conduct rational analysis based on engineering-related background knowledge, evaluate the impact of professional engineering practices and solutions to complex engineering problems on society, health, safety, law, and culture, and understand the responsibilities to be assumed." g) Environment and Sustainable Development: "Able to understand and evaluate the impact of engineering practices for complex engineering problems on the environment and social sustainable development." h) Professional Ethics: "Possessing humanistic and social science literacy, a sense of social responsibility, and the ability to understand and abide by engineering professional ethics and standards, fulfilling responsibilities in engineering practice."

References

ABET. (2006). *Graduate attributes and professional competency profiles for the engineer, Engineering technologist, and engineering technician*. ABET, Inc.

ABET. (2018). *Criteria for accrediting engineering programs, 2019–2020*. ABET, Inc. https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2019-2020/#GC3

ABET. (n.d.). *ABET's role in global accreditation*. ABET, Inc. https://www.abet.org/accreditation/get-accredited/accreditation-outside-the-u-s/

Akera, A., Appelhans, S., Cheville, A., De Pree, T., Fatehiboroujeni, S., Karlin, J., & Riley, D. M. (2019). ABET & engineering accreditation - History, theory, practice: Initial findings from a national study on the governance of engineering education. *Proceedings of the 2019 ASEE Annual Conference & Exposition*. https://peer.asee.org/32020

Altbach, P. G. (2003). Academic colonialism in action: American accreditation of foreign universities. *International Higher Education, 32*, 5–7. https://ejournals.bc.edu/index.php/ihe/article/view/7373

Augusti, G. (2007). Accreditation of engineering programmes: European perspectives and challenges in a global context. *European Journal of Engineering Education*, *32*(3), 273–283.

Augusti, G. (2010). EUR-ACE: A common European quality label for accredited engineering programs. *Proceedings of the 2010 International Conference on Engineering Education (ICEE-2010)*.

Augusti, G., Birch, J., & Payzin, A. E. (2011). *EUR-ACE: A system of accreditation of engineering programmes allowing national variants.* https://www.mudek.org.tr/doc/sun/20110405%28Augusti-Birch-Payzin-INQAAHE2011-paper%29.pdf

Brittingham, B. (2009). Accreditation in the United States: How did we get to where we are? *New Directions for Higher Education*, *145*, 7–27. https://doi.org/10.1002/he.331

Canadian Accreditation Board (CAB), The. (1975). *1st annual report*. The Canadian Council of Professional Engineers.

Canadian Accreditation Board (CAB), The. (1976). *Annual report - June 1976*. The Canadian Council of Professional Engineers.

Canadian Engineering Accreditation Board (CEAB), The. (1987). *Canadian engineering accreditation board - 1986/1987 report.* The Canadian Council of Professional Engineers.

Canadian Engineering Accreditation Board (CEAB), The. (1990). *Canadian engineering accreditation board - 1989/1990 annual report.* The Canadian Council of Professional Engineers.

Canadian Engineering Accreditation Board (CEAB), The. (1993). *Canadian engineering accreditation board - 1993 annual report.* The Canadian Council of Professional Engineers.

Canadian Engineering Accreditation Board (CEAB), The. (1996). *1996 accreditation criteria and procedures*. The Canadian Council of Professional Engineers.

Canadian Engineering Accreditation Board (CEAB), The. (2008). *Accreditation criteria and procedures - 2008*. The Canadian Council of Professional Engineers.

Cao, G.H. (2015). Comparison of China-US engineering ethics educations in sino-western philosophies of technology. *Sci Eng Ethics*, *21*, 1609–1635. https://doi.org/10.1007/s11948-014-9611-3

Chapman, C. R., & Levy, J. (2004). An engine for change: A chronicle of the engineering council. Engineering Council UK.

China Engineering Education Accreditation Association (CEEAA). (2022a). 工程教育认证标准[Engineering education accreditation criteria]. https://www.ceeaa.org.cn/gcjyzyrzxh/rzcxjbz/gcjyrzbz/tybz/630662/index.html

China Engineering Education Accreditation Association (CEEAA). (2022b). 工程教育认证通用标准解读及使用指南(2022版) [Interpretation and user guide of universal standards for engineering education accreditation (2022 ed.)]. http://jxyzyrz.swu.edu.cn/info/1005/1380.htm

Committee on Evaluation of Engineering Education (CEEE). (1994). Report on evaluation of engineering education (reprint of the 1955 report). *Journal of Engineering Education*, *93*(1), 74–94.

Dodgen, R. A. (2001). *Controlling the dragon: Confucian engineers and the Yellow River in late Imperial China*. University of Hawai'i Press.

Downey, G. L., Lucena, J. C., & Mitcham, C. (2007). Engineering ethics and identity: Emerging initiatives in comparative perspective. *Science and Engineering Ethics*, *13*(4), 463–487.

El-Khawas, E. (2007). Accountability and quality assurance: New issues for academic inquiry. In J. F. James & P. G. Altbach (Eds.), *International handbook of higher education* (pp. 23–37). Springer.

Engineers' Council for Professional Development (ECPD). (1971). *39th annual report year ending Sept. 30, 1971*. Engineers' Council for Professional Development.

Engineers' Council for Professional Development (ECPD). (1973). *41st annual report year ending Sept. 30, 1973*. Engineers' Council for Professional Development.

Engineers' Council for Professional Development (ECPD). (1974). *42nd annual report year ending Sept. 30, 1974*. Engineers' Council for Professional Development.

Engineers' Council for Professional Development (ECPD). (1975). *43rd annual report year ending Sept. 30, 1975*. Engineers' Council for Professional Development.

Engineers' Council for Professional Development (ECPD). (1979). *47th annual report year ending Sept. 30, 1979*. Engineers' Council for Professional Development.

European Network for Accreditation of Engineering Education (ENAEE). (2021). *EUR-ACE framework standards and guidelines (EAFSG)*. https://www.enaee.eu/wp-content/uploads/2022/03/EAFSG-04112021-English-1-1.pdf

European Network for Accreditation of Engineering Education (ENAEE). (n.d.). *Database of EUR-ACE labelled programmes*. https://eurace.enaee.eu/node/163

Engineering Professors' Council (EPC). (2022). Welcome to the engineering ethics toolkit. https://epc.ac.uk/article/welcome-to-the-engineering-ethics-toolkit/

Harcleroad, F. F. (1980). *Accreditation: History, process, and problems* (AHE-ERIC/Higher education research report No. 6). National Institute of Education.

Hodge, S. (2007). The origins of competency-based training. *Australian Journal of Adult Learning*, *47*(2), 179–209.

International Engineering Alliance (IEA). (2013). *Graduate attributes and competency profiles*. https://www.ieagreements.org/assets/Uploads/Documents/Policy/Graduate-Attributes-and-Professional-Competencies.pdf

International Engineering Alliance (IEA). (2015). *A history of the International Engineering Alliance and its constituent agreements: Toward global engineering education and professional competence standards*. https://www.ieagreements.org/assets/Uploads/Documents/History/IEA-History-1.1-Final.pdf

International Engineering Alliance (IEA). (n.d.). Washington Accord – Signatories. https://www.ieagreements.org/accords/washington/signatories/

Iseda T. (2008). How should we foster the professional integrity of engineers in Japan? A pride-based approach. *Science and Engineering Ethics*, *14*(2), 165–176.

Japan Accreditation Board of Engineering Education (JABEE). (2016). *JABEE category-dependent criteria for accreditation of professional education programs*. JABEE. https://jabee.org/doc/12334.pdf

Kanemitsu, H. (2021). *How accreditation leads to Japanese-specific teaching materials for Japanese-specific engineering ethics*. SEFI. https://www.sefi.be/2021/02/24/how-accreditation-leads-to-japanese-specific-teaching-materials-for-japanese-specific-engineering-ethics/

Kenichi, N. (2021). *Japan's engineering ethics and Western culture: Social status, democracy, and economic globalization*. Lexington Books.

King, L. S. (1982). IV. The founding of the American Medical Association. *JAMA*, *248*(14), 1749–1752. https://doi.org/10.1001/jama.1982.03330140059036

King, L. S. (1983). IX. The AMA gets a new code of ethics. *JAMA, 249*(10), 1338–1342. https://doi.org/10.1001/jama.1983.03330340072038

Klassen, M. (2018). *The politics of accreditation: A comparison of the engineering profession in five anglosphere countries* (Unpublished master's thesis). University of Toronto, Toronto, Ontario, Canada.

Kobayashi, Y., & Fudano, J. (2016). 「技術者倫理教育における学習・教育目標2016」および「モジュール型モデル・シラバス」解説 ["Learning and educational objectives in technical ethics education 2016" and the explanation of the "module-based model syllabus"]. *Journal of Engineering Education/*工学教育, *64*(5), 141–159.

Lattuca, L., Terenzini, P. T., & Wolkwein, J. F. (2006). *Engineering change: A study of the impact of EC2000*. ABET, Inc.

Li, Z. (2017). 对我国工程教育专业认证十年的回顾与反思之二 [A review and reflection on ten years of engineering education professional accreditation in our country: Part two]. http://meea.cmes.org/article?id=188

Lin, H. (2021). Examination essays, paratext, and Confucian orthodoxy: Negotiating the public and private in knowledge authority in early seventeenth-century China. In M. Green, L C. Norgaard & M. B. Bruun (Eds.), *Early modern privacy* (pp. 297–314). Brill.

Lucena, J., Downey, G. L., Jesiek, B. K., & Ruff, S. (2008). Competencies beyond countries: The re-organization of engineering education in the United States, Europe, and Latin America. *Journal of Engineering Education*, *97*(4), 433–447. https://doi.org/10.1002/j.2168-9830.2008.tb00991.x

Maassen, P. A. M. (1997). Quality in European higher education: Recent trends and their historical roots. *European Journal of Education*, *32*(2), 111–127. http://www.jstor.org/stable/1503543

Matos, S. M., Riley, D. M., & Akera, A. (2017). WannABET? Historical and organizational perspectives on governance in engineering education. *Proceedings of the 2017 ASEE Annual Conference & Exposition.* https://peer.asee.org/29110

Min, H., & Xiuwen, Y. (2001). Educational assessment in China: Lessons from history and future prospects. *Assessment in Education: Principles, Policy & Practice*, *8*(1), 5–10. https://doi.org/10.1080/09695940120033216

Nodine, T. R. (2016). How did we get here? A brief history of competency-based higher education in the United States. *Competency-based Education*, *1*(1), 5–11. https://doi.org/10.1002/cbe2.1004

O'Sullivian, B., & Cheng, L. (2022). Lessons from the Chinese imperial examination system. *Language Testing in China*, *12*, Article 52.

Parker, J. M., III. (1961). Geological engineering curricula. *Journal of Geological Education*, *9*(1), 13–18.

Prados, J. (2008). Accreditation of undergraduate curricula. In *AIChE Centennial 1908–2008: A century of achievements* (Chapter 19). American Institute of Chemical Engineering (AIChE).

Pritchard, M. (1990). Beyond disaster ethics. *The Centennial Review*, *34*(2), 295–318.

Sánchez-Chaparro, T., Remaud, B., Gómez-Frías, V., Duykaerts C., & Jolly, A.-M. (2022). Benefits and challenges of cross-border quality assurance in higher education. A case study in engineering education in Europe. *Quality in Higher Education*, *28*(3), 308–325.

Sato, Y., & Harada, S. (2005). JABEEに関するアンケート集計結果 [Survey Results on JABEE]. *Journal of Engineering Education*/工学教育, *53*(3), 101–112.

Stephan, K. D. (2002). All this and accreditation too: A history of accreditation requirements. *IEEE Technology and Society Magazine*, Fall 2002, 8–15.

Stoeckel, A. L. (1958). *Politics and administration in the early colonial colleges* (Unpublished doctoral thesis). University of Illinois, Urbana, Illinois.

UK Engineering Council (UKEC). (1998). 2.1.1 - Roles and responsibilities of chartered engineers. *SARTOR 3rd Edition Part 2 Document.* https://web.archive.org/web/20000903215442/http://www.engc.org.uk/sartor/

UK Engineering Council (UKEC). (2004). *The Accreditation of Higher Education Programmes (AHEP1) first edition*.

UK Engineering Council (UKEC). (2013). *The Accreditation of Higher Education Programmes (AHEP2) second edition*.

UK Engineering Council (UKEC). (2014). *The Accreditation of Higher Education Programmes (AHEP3) third edition*. https://www.engc.org.uk/EngCDocuments/Internet/Website/Accreditation%20of%20Higher%20Education%20Programmes%20third%20edition%20(1).pdf

UK Engineering Council (UKEC). (2017). *Ethical statement*. https://www.engc.org.uk/media/2334/ethical-statement-2017.pdf

UK Engineering Council (UKEC). (2020). Accreditation of Higher Education Programmes (AHEP4) fourth edition. https://www.engc.org.uk/media/3410/ahep-fourth-edition.pdf

Van Vught, F. A., & Westerheijden, D. F. (1994). Towards a general model of quality assessment in higher education. *Higher Education, 28*, 355–371. https://doi.org/10.1007/BF01383722

Wang, S., Zhao, Z., & Lei, H. (2014). 中国工程教育认证制度的构建与完善 [Construction and improvement of China's engineering education accreditation system]. *Research in Higher Engineering Education*/高等工程教育研究, *5*, 23–34.

Wickenden, W. E. (1934). Final report of the director. In *Report of the Investigation of Engineering Education 1923-1929, Volume II* (pp. 1041–1116). Society for the Promotion of Engineering Education.

Weil, V. (1984). The rise of engineering ethics. *Technology in Society*, *6*(4), 341–345. https://doi.org/10.1016/0160-791X(84)90028-9

Wisnioski, M. (2016). *Engineers for change: Competing visions of technology in 1960s America*. The MIT Press.

Xavier, P., Wint, N., & Orbaek White, G. (2023). A snapshot of how 'social' considerations are currently being interpreted and addressed within engineering education and accreditation. In *Engineering, social sciences, and the humanities: Have their conversations come of age?* (pp. 65–92). Cham: Springer International Publishing.

Zhang, H., & Davis, M. (2018). Engineering ethics in China: A century of discussion, organization, and codes. *Business & Professional Ethics Journal*, *37*(1), 105–135. http://www.jstor.org/stable/45149312

Zhu, Q., Jesiek, B., & Yuan, J. (2014). Engineering education policymaking in cross-national context: A critical analysis of engineering education accreditation in China. *Proceedings of the 2014 ASEE Annual Conference & Exposition*. https://peer.asee.org/20388