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# A Comparative Institutional Analysis of Engineering Ethics in the Netherlands and the United States

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**ABSTRACT**

This paper investigates the drivers behind the institutionalization of engineering ethics at the national level through a comparative study of the United States and the Netherlands. The study examines the historical evolution and current landscape of engineering ethics activities in both countries. By comparing emergence, process, and actor involvement dimensions, commonalities and differences between the two nations' approaches to the institutionalization of engineering ethics are identified. The analysis reveals context-specific factors shaping engineering ethics policies, including the nature of the profession, technological challenges, and societal attributes. The study identifies common drivers for national engineering ethics development: external influences such as technological crises and societal debates, contextual forces like institutional dynamics and societal attributes, and the triple helix of academia, professional associations, and government relations. The findings may offer useful insights for policymakers and practitioners seeking to enhance engineering ethics.

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Engineering ethics; national engineering ethics; comparative study; institutional analysis; United States; Netherlands

## 1. Introduction

The field of engineering ethics, as an academic discipline and an institutionalized activity, is approaching its 50th anniversary since it began to take shape in the US in the 1970s.[1] Throughout this period, numerous countries have introduced engineering ethics initiatives. They have adopted ethical codes of conduct and established courses at universities. Scientists, policymakers, and technology developers are now looking back to evaluate the developments of engineering ethics over the past five decades to learn from their experiences and those of others.

Previous research has shown that the contents, methods, and actors involved in developing engineering ethics in different countries vary.[2] Downey et al. have highlighted how engineering identity shapes ethical perspectives across national settings.[3] Didier has analyzed differences between the United States and Europe by emphasizing the roles of professional organizations, educational institutions, and intellectual traditions,[4] and Luegenbiehl has compared conceptions of professional autonomy in Japan and the United States.[5] These studies suggest that engineering ethics is deeply embedded in national

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and cultural contexts. We present a country-level comparison of the institutionalization of engineering ethics in the Netherlands and the US aimed at formulating drivers for the development of engineering ethics.

By 'engineering ethics,' we mean not just academic research or teaching, but the broader set of (institutionalized) activities that contribute to ethical reflection on, and guidance of engineering in a country, such as codes of conduct. In our usage, 'engineering ethics' is a broad concept that includes both professional engineering ethics, which addresses the moral responsibilities of engineering agents, and the ethics of technology, which concerns the ethical dimensions and impacts of technologies. Accordingly, what we will call 'national engineering ethics' encompasses all activities and outcomes within a country that affect ethical reflection and guidance of engineering, including research, education, and professional conduct.[6] This definition includes the roles of governments and governmental organizations, engineering professional and scientific societies, and the academic and professional works of individual philosophers, scientists, and engineers in shaping national engineering ethics.

We acknowledge that countries are not homogeneous and that multiple approaches to engineering ethics may coexist within a single national context. The nation state is therefore used as a heuristic level of analysis rather than as a claim of internal uniformity. Nevertheless, analyzing engineering ethics at the country level remains meaningful for two reasons. First, many of the institutions that shape engineering ethics – such as education systems, professional regulation, and governmental policies – are largely organized at the national level. Second, prior research in engineering studies has productively used cross-national comparisons to show how engineering identities and ethical expectations vary across nations.[7] Moreover, our earlier work introducing the National Engineering Ethics (NEE) framework emphasized that engineering ethics develops within specific national contexts and cannot simply be transferred from one country to another without considering contextual conditions.[8]

In identifying drivers for the implementation and institutionalization of national engineering ethics, we take a comparative approach. We compare the US and the Netherlands, both recognized for their significant contributions to the field. Moreover, there is extensive information in the literature regarding the development of national engineering ethics in both countries. Our aim is not to provide a full or new understanding of the historical development of engineering ethics in both countries, but to compare selected engineering ethics-related activities, key actors, and aspects of the current context in these two countries. Detailed studies exist on particular aspects of these developments. For example, classroom-level engineering ethics education has been examined in both countries, for example, by Hess and Fore[9] in the United States and by Van de Poel et al.[10] in the Netherlands.

Our study uses the National Engineering Ethics (NEE) framework developed in an earlier publication.[11] The NEE framework builds on the Institutional Analysis and Development (IAD) Framework, developed by Elinor Ostrom,[12] which aims to analyze the institutional environment of a collective problem from an actor-centered institutional perspective. The NEE framework helps to identify categories of actors in the field, the activities that they conduct, and the contextual factors that influence their decision-making processes.

The comparative institutional analysis identifies three interrelated drivers that have presumably shaped the institutionalization of national engineering ethics in both the US and the Netherlands: (1) external influences, which refers to broader social, political, economic, and technological forces that affect the engineering ethics environment from outside; (2) contextual forces, referring to institutional, cultural, and material conditions that are internal to the engineering ethics environment – such as educational regulations, community norms, and the practical settings in which engineering activities take place – that enable or constrain its development; and (3) the triple helix, or collaborative interactions among academia, government, and professional associations. Together, these three drivers provide a basis for understanding the development of engineering ethics at the national level.

The article begins by detailing the theoretical background and methodology. We then present the actions of governments and organizations related to the development of engineering ethics in the US and the Netherlands. Next, we compare these developments in the two countries. Finally, we identify three drivers that help explain the development of national engineering ethics.

## 2. Conceptual background: the NEE framework

The NEE framework is a tool for methodically describing engineering ethics activities in a country and the contextual factors affecting them. We developed it in our earlier work[13] through an adaptation of Ostrom's IAD framework, informed by the engineering ethics literature and empirical familiarity with engineering ethics activities in different national contexts.

This framework includes the NEE environment, contextual factors, and evaluation criteria. The central part of the framework, as illustrated in Figure 1, is the NEE environment, which encompasses all engineering ethics activities. These activities are categorized into nine action arenas based on three levels: research, education, and professional conduct, as well as three pillars: governmental, organizational, and operational.

In this framework, the distinction between governmental, organizational, and operational levels is analytical and refers to different types of activities rather than fixed categories of actors. The governmental level concerns activities related to the formulation of formal rules, legislation, and public policies that structure the engineering ethics environment. The organizational level refers to activities in which these rules and policies are interpreted, translated, and operationalized into programs, guidelines, educational initiatives, and research agendas by various organizations. The operational level concerns the implementation and enactment of these programs and guidelines in concrete practices, such as teaching in classrooms, conducting research projects, and professional engineering work. In this article, we focus primarily on the governmental and organizational levels.

The contextual factors on the left side of the framework comprise biophysical and material factors, attributes of the community, and institutions. Institutions comprise a set of formal and informal rules that impact the activities conducted in relation to national engineering ethics. These institutions include laws, regulations, informal arrangements, and shared routines. Examples of contextual factors include educational structures, professional norms, and intellectual traditions.

The framework also includes external influences, which comprise broader economic, cultural, and political developments that affect the engineering ethics environment. Examples include natural disasters such as earthquakes and tsunamis, political issues such as wars,

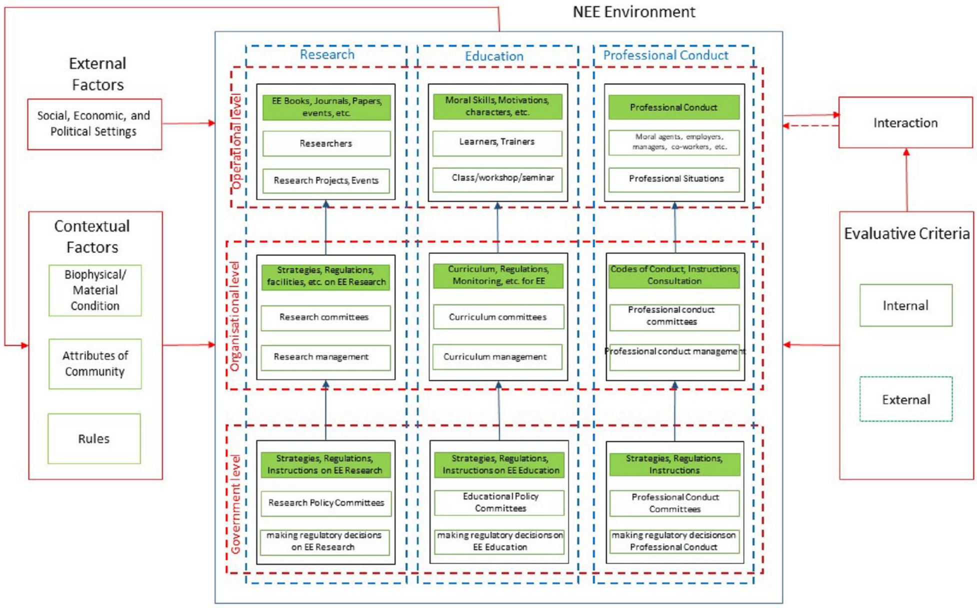


**Figure 1.** The National Engineering Ethics (NEE) Framework.[96]

and economic or political crises in countries. In our analysis, these two types of factors are distinguished by their relation to the engineering ethics environment: contextual factors operate within this environment, while external influences originate outside it and impact it from the broader societal context. The framework also includes interactions and evaluation criteria.

The NEE framework provides categories for the identification of action situations, actors, their interactions, and output in a systematic way. It also provides pointers to collect relevant data from different resources and to analyze the potential interrelations among various factors to examine why and how developments of engineering ethics have taken place. As our goal was to compare two countries, we paid special attention to the policy-making level and the higher-level institutional developments that have taken place in each country. Therefore, the operational level of the framework was left unexplored.

The NEE framework has both strengths and limitations for analyzing engineering ethics at the national level. Its main strength lies in approaching engineering ethics not as a set of isolated, individual, or fragmented actions, but as a field of interacting activities shaped by organizations across different domains and levels, rules, and contextual conditions. In this sense, it helps reveal how engineering ethics in a country develops through the interactions among universities, professional organizations, governments, policies, and other actors, rather than simply through the actions of 'good' or 'bad' engineers. The framework is also sensitive to contextual factors, reflecting the emphasis placed in the engineering ethics literature on the importance of national context. Taken together, these features provide a structured basis for systematically comparing engineering ethics across different countries.

Nevertheless, the framework also has limitations. Its institutional orientation may understate the role of influential individuals, intellectual traditions, informal cultures and practices, power relations, conflicts, and discursive struggles around concepts such as profession, engineering, or responsibility. In addition, the framework may present engineering ethics activities as more organized and coherent than they are in practice, particularly in contexts where such activities are fragmented, loosely connected, or continuously evolving. Moreover, while the distinction between contextual forces and external influences is conceptually useful, it is not always straightforward to apply in practice, as some developments may be interpreted as belonging to both categories. Similarly, the evaluative dimension of the framework still requires further development for application to national engineering ethics. Further refinement of these contextual and evaluative dimensions may strengthen the framework's analytical capacity.

## 3. Methodology

The aim of the article is to present an institutional comparison of the development of engineering ethics in the United States and the Netherlands, with a focus on identifying possible common drivers. Because our aim is not to provide a detailed historical account of the development of engineering ethics in the US and the Netherlands, we provide a brief and, at some points, somewhat schematic historical overview of the development of engineering ethics in these two countries and give an institutional snapshot of the current state of affairs in these countries. Our comparative institutional approach addresses three dimensions: (1) emergence: *why* engineering ethics came into being in the first place; (2) process: *how* engineering ethics developed; and (3) actor involvement: *who* were the players in this development.

Data for this study were collected primarily through a review of relevant documents, supplemented by interviews with key experts. For the desk research, we first identified relevant factors for the analysis on the basis of the NEE framework. Subsequently, we conducted an extensive search for academic publications, government reports, and official websites from relevant organizations based on these factors. Publications and other documents were identified through database searches (e.g. Google Scholar) and snow-balling (reference tracing). A selection of publications, reports and websites was made based on their relevance to the variables of the NEE framework. These variables included the activities of governmental and organizational actors, as well as institutional arrangements related to engineering ethics research, education, and professional conduct.

Although engineering ethics in the sense of ethical reflection on engineering is arguably as old as engineering itself, the *institutionalization* of engineering ethics, including the emergence of a (scientific) discipline studying engineering ethics as well as systematic teachings on the subject, started no earlier than the 1970s.[14] Thus, we examined the actions taken by governments and organizations in both countries since the 1970s. Furthermore, we briefly considered broader societal conditions and early ethical activities prior to the 1970s that laid the groundwork for later developments. Furthermore, earlier background factors identified in the documents were followed up through their references to trace underlying conditions.

To complement, contextualize and triangulate the desk research findings, we conducted interviews with four key experts in the field of engineering ethics who have played significant roles in the development of the discipline in either the US or the Netherlands: Rachelle Hollander, Joseph Herkert, Peter Kroes, and Anthonie Meijers.[15]

Next, data from the two countries were mapped on, and compared with respect to each of the nine action arenas of the NEE environment (Figure 1), responding to the three questions of why, how, and who for each country.

The research has the following limitations. Only a small number of interviews with four key individuals were held for triangulation. Moreover, only publicly available sources were used. Also, the operational level of action situations, such as classrooms, research groups, and engineering workplaces, remained unexplored because we aimed to provide an institutional comparison rather than a detailed historical account of the development of engineering ethics in the United States and the Netherlands. Future research could address both of these limitations through additional empirical research.

## 4. An analysis of national engineering ethics institutionalization in the US and the Netherlands

This section examines the most significant governmental and organizational actions in the areas of research, education, and professional conduct, as well as the contextual and external factors that influenced the development of engineering ethics in the US and the Netherlands, as mentioned in Figure 1. Regarding the organizations, we focus on the key episodes or activities that had the greatest influence on the process rather than describing all the ones that contributed to the development. This section highlights selected initiatives that help sketch the broader landscape of national engineering ethics activities.

### *4.1. The development of national engineering ethics in the US*

While engineering was born in France,[16] engineering ethics as a more systematic and institutionalized activity emerged in the United States. This country is often regarded as a leader in engineering ethics, particularly when it comes to the role of professional engineering societies. This section scrutinizes the role of governments and organizations in the development, as well as the external influences and contextual forces that influenced this process, as defined earlier in the paper.

#### *4.1.1. The government level in the US*

This section highlights key initiatives by public authorities in the US that have contributed to the development of engineering ethics. The term 'government' here is used in a broad sense and also includes national institutions such as the National Science Foundation (NSF) and the National Council of Examiners for Engineering and Surveying (NCEES).

To facilitate comparison with the Netherlands, governmental actions are discussed under five themes: legislation and regulation; interaction with professional organizations; support for research and higher education; institutional infrastructures; and actions against ethical violations.

*Legislation and regulations:* Government entities have played a crucial role in shaping the engineering profession via legislation and regulations. These governmental initiatives were often reactive, influenced by vanguard academics seeking funding, professional societies facing engineering disasters, and rising societal concerns, as explained below.

We highlight a range of specific legislative and regulatory measures. One is state licensure laws, which require engineers to be licensed. While such laws typically exempt engineers in industry from licensure,[17] which is probably the majority of engineers in the US, they still have an important symbolic meaning. They suggest that working as an engineer requires certain ethical skills. They often tie eligibility for licensure to graduation from accredited programs that mandate ethics instruction (e.g. ABET EC2000, though ABET is a non-governmental body). Another example is the federal ethics training requirement introduced by the America COMPETES Act for ethics training in NSF-funded graduate education. Governments have also mandated ethics and compliance programs for federal contractors (e.g. FAR 3.1002),[18] and established conflict-of-interest regulations (e.g. FAR Subpart 9.5 and Part 3). In addition, safety and environmental regulations (e.g. under the OSH and Clean Air Acts), corporate compliance mandates (e.g. DOJ guidelines; Sarbanes–Oxley Act for public firms), and state-level laws addressing specific issues (e.g. California Business and Professions Code, Section 6730[19]) have further shaped the ethical obligations of engineers. Finally, laws promoting specific ethical conduct, such as the Whistle-blowers Protection Act,[20] [21] reinforce the broader culture of accountability within the engineering profession.

*Interaction with professional engineering organizations:* Federal and state governments and institutions interact with professional engineering organizations in various ways, including relying on bodies like the Accreditation Board for Engineering and Technology (ABET) for the accreditation of engineering education institutes; cooperating with engineering associations (through state governments) in tasks relating to the licensure, such as the operations of the state licensure boards and their exams; providing financial support through agencies like the NSF; enabling coordination across jurisdictions through institutions such as the NCEES, a national body for state engineering boards; and partnership and collaboration to advance shared goals, such as promoting innovation[22] and sustainability.

*Support for research and higher education:* Engineering ethics academic programs in the United States have been supported in different ways: government agencies such as the NSF, National Endowment for the Humanities (NEH), and the National Aeronautics and Space Administration (NASA) have provided financial support, while organizations such as the National Academy of Engineering (NAE) and ABET have contributed through consultation, guidance, and standard-setting.

*Institutional infrastructures:* The US government contributed to the institutionalization of ethical conduct in engineering by creating or helping to establish key organizations and programs. These include state engineering boards and federal agencies such as the National Institute of Standards and Technology (NIST). It also formed dedicated ethics programs within federal agencies – such as the Ethics Education in Science and Engineering (EESE) program within the NSF.

*Actions against ethical violations of engineers:* As the engineering profession is regulated by state licensing boards in the United States, lapses in professional practice, including violations of the NSPE code of conduct or other Codes of Ethics endorsed by the state, can result in disciplinary action by state licensing boards. Although such disciplinary actions only seem to be taken in exceptional cases, the consequences of these violations can nevertheless be severe, including fines, suspension or revocation of licensure, and even criminal charges in some cases. For instance, in 2015, the Texas Board of Professional Engineers revoked the license of an engineer who had signed off on the structural plans for a Dallas Cowboys practice facility that collapsed, injuring several people.[23]

* * *

While government efforts have contributed meaningfully to the institutionalization of engineering ethics in the United States, several limitations and concerns remain. Licensure laws, for instance, include exemptions for industrial practice, which is significant given that the majority of engineers work in industry and are therefore not subject to licensing requirements. Moreover, disciplinary enforcement is fragmented license revocation is rare, and engineers disciplined in one state may continue to practice in another. Even in serious cases, such as the Hyatt Regency walkway collapse, revoking licensure has proven legally and institutionally burdensome. In addition, some interviewees expressed concern that recent administrative decisions in the US may impede further progress, citing the cancellation of federal support for certain ethics-related research projects, including those connected to technology and societal issues such as climate change and diversity.[24] The inclusion of engineering ethics in funding programs was often the result of long-term academic efforts to bring these topics to institutional attention.

#### *4.1.2. The organizational level in the US*

The first organizations to react to public demand and concern about a number of technical disasters were professional engineering associations.[25] They have been crucial in the country's development of engineering ethics. With their timely support in the mid-1970s, government bodies like the NSF and NEH had a significant influence on the institutionalization of research in engineering ethics. Also, foundations like the Rockefeller Brothers and the Carnegie Foundations made substantive contributions to support engineering ethics research initiatives.[26] In addition, (technological) universities have played leading roles in developing the academic field of engineering ethics. Moreover, some of them interact with professional associations, having a direct impact on enhancing professional conduct.

To facilitate comparison with the Netherlands, we distinguish here between funding organizations, academic research centers, and professional associations.

*Funding organizations:* The US National Science Foundation (NSF) is a federal agency that supports science and engineering primarily through research grants. In the late twentieth century, it accounted for about 25% of federal funding for research at American universities.[27] In the early stages of the development of engineering ethics, the NSF has played an important role – as an impetus – by defining and financially supporting research and education projects. Beginning in 1975, it regularly funded ethics and value research, averaging about 15 projects annually.[28]

*Academic research centers:* The first interdisciplinary center of its sort to concentrate on ethics in the professions was the Center for the Study of Ethics in the Professions (CSEP), established in 1976 at the Illinois Institute of Technology.[29] Hollander et al.[30] argue that it has remained a leading center for engineering ethics worldwide for over forty years. The center manages the world's largest online repository of ethics codes. Furthermore, CSEP collaborates with professional societies, aiding in the development and updating of ethics programs and codes.

*Professional associations:* Licensed professional engineers in the United States are represented by the National Society of Professional Engineers (NSPE). The NSPE -founded in 1934–protects engineers and the public from unqualified practitioners, creates public awareness about the profession, and combats unethical practices and inadequate compensation. The NSPE has supported engineering ethics through multiple activities, including developing and revising its Code of Ethics, promoting ethics education, and publishing professional guidelines. Among these, the work of its Board of Ethical Review (BER) – which issues interpretive case-based judgments to clarify the code – has been particularly influential in guiding engineers' ethical decision-making. While the NSPE is a general professional association, there are more specific professional associations for different engineering fields, several of which have played active roles in engineering ethics.

Despite these accomplishments, interviewees also highlighted important limitations in organizational efforts in the US. According to the interviewees, much of the progress relied on the initiatives of committed individuals – both academics and professionals. Professional societies, while influential, often moved inconsistently: their promotion of ethics has had an up-and-down history, with codes of ethics not always translated into practice and even periods of dormancy in ethics committees. Some members resisted ethical engagement altogether, viewing engineering as a neutral activity. Likewise, ABET's requirements have not been stringent enough to ensure uniform progress in universities, many of which still do not offer stand-alone ethics courses despite ABET 2000. NSF's support has also fluctuated, with some ethics education funding lines becoming inactive. Organizational contributions, while pivotal, were partial and uneven – often depending on the drive of individuals.

#### *4.1.3. External and contextual factors that impacted national engineering ethics in the US*

In this section, we analyze the role of external influences and contextual forces in shaping the development of engineering ethics in the United States, i.e. factors originating outside and within the engineering ethics environment, respectively.

*1970s – 1990s, the era of engineering ethics as professional ethics:* Although engineering ethics had not yet emerged as a distinct field before the 1970s, earlier societal and intellectual developments – including the societal concerns associated with the World Wars and the Vietnam War, environmental concerns, the STS movement, and the dominance of classical philosophies of technology – created important external and contextual conditions for its later institutionalization. While the emergence of STS studies contributed to growing reflection on the societal implications of technology, the common idea among engineers that technology is value-free impeded serious ethical discussions among scientists and the establishment of ethics courses.

The period between the 1970s and 1990s was the era of the growth of engineering ethics in the US.

In the early 1970s, a shift towards more philosophical reflection on technology, supported by entities like the NSF, led to the emergence of philosophical and ethical studies in science and engineering. Initially focusing on the societal impacts of new technologies, the attention later shifted to ethical considerations within engineering practice. Events like the atomic bombing and a series of major accidents such as Three Mile Island, Bhopal, the Challenger explosion, Chernobyl, the Exxon Valdez oil spill, the Pinto gas tank explosions, and the Hyatt Regency walkway collapse, fueled this shift.[31] Some attribute the 1970s surge in ethics attention to societal corruption,[32] while others argue it was a response to growing concerns about the dangers of technology.[33] Davis suggests that the catalyst was an ethics downturn in preceding decades.[34]

With media attention on engineering scandals, public concern grew,[35] prompting governments and companies to take action.[36] The NSF- and NEH-funded programs brought together engineers and philosophers in the late 1970s.[37] Rensselaer Polytechnic Institute (RPI) and the Illinois Institute of Technology (IIT) established research centers, empowering philosophers to lead new courses and research in the late 1970s. Simultaneously, the Hastings Center, supported by the Rockefeller Brothers Fund and Carnegie Corporation of New York, systematically studied ethics in higher education, including engineering, from 1977.[38] Additionally, professional associations, notably the Engineers Council for Professional Development (ECPD) in 1974, revised codes with vigor,[39] incorporating the 'paramountcy clause' requiring engineers to hold the health, safety, and welfare of the public as paramount. In the 1980s, NSF-supported textbooks, like 'Ethics in Engineering',[40] were published, marking a significant milestone for the field.[41] ABET Engineering Criteria 2000, in the 1990s, mandated 'an understanding of professional and ethical responsibility' for accreditation, addressing concerns about the slow institutionalization of engineering ethics in education.[42]

*From the 2000s onwards, the era of integrating engineering ethics and STS:* Since 2000, the scope of engineering ethics topics has further expanded,[43] a development interpreted in different ways.[44] While Johnson and Wetmore attribute the shift in the early twenty-first century to the influence of European philosophers,[45] notably the Dutch, another influential factor emerged domestically. Initial ethical efforts in the 1970s focused on emerging technologies but shifted in response to engineering scandals. Completing the institutionalization of engineering ethics in the early 2000s opened avenues for policymakers and organizations like NSF to expand the discussion of other ethical topics. In contrast to earlier periods, this expansion was primarily shaped by contextual forces within an already established engineering ethics environment, rather than by external influences. This trajectory was further consolidated through the America COMPETES Act of 2007, which encouraged the NSF to extend its support beyond undergraduate programs to graduate education and wider institutional change.

### 4.2. The development of national engineering ethics in the Netherlands

Like the US, the Netherlands is known as one of the leading countries in engineering ethics.[46] The first steps in engineering ethics in this country were taken before World War I with the establishment of professional engineering organizations and the development of professional codes of conduct.[47] Between the 1960s and the 1990s, the country developed a strong tradition in STS and Technology Assessment (TA). While these fields did not provide a philosophical foundation for ethics of technology, they created an environment in which awareness of the ethical and societal significance of engineering and technology could grow.[48] In this period, the development of engineering ethics in other countries, like the US, also affected the developments in the Netherlands.[49]

#### 4.2.1. The government level in the Netherlands

Since the 1960s, the Dutch government has played an important role.[50] Below, we describe the main developments and actions under the five headings of legislation and regulation, interaction with professional organizations, support for research and higher education, institutional infrastructures, and actions against ethical violations.

*Legislation and regulation:* Laws for ethics education in technology and engineering were introduced in the years 1960 and 1992. In 1960, the Dutch Parliament passed a new Higher Education Act. This act stated that 'universities [should] pay attention to the advancement of a sense of social responsibility.' However, the act did not effectuate any real changes in university education until the next decade,[51] when it led to the introduction of courses relating to especially STS in the university curricula.[52] In 1992, another Higher Education Act was passed, stating that 'universities and polytechnics, among other things, should pay attention to personal development and the promotion of societal responsibility.' While the law did not mandate ethics courses, it inspired technological universities to consider ethics courses.[53] In addition, the government also responded to public and expert concerns regarding the social and ethical implications of emerging technologies, including ICT, biotechnology, and studies involving human subjects and animal experiments. In 1993, a report of the Ministry of Education examined the desirability of ethical codes of conduct for scientists and engineers. It suggested advisory codes for engineers in the Dutch context to navigate problems, but cautioned against using professional codes for legal regulation.[54]

*Interaction with professional organizations:* Compared with the United States, the literature provides fewer examples of direct governmental interaction with professional engineering organizations in shaping engineering ethics in the Netherlands. Instead, professional associations such as KIVI have largely developed their own initiatives in this area.

*Support for research and higher education:* In the Netherlands, research in ethics and technology started to be supported in the 1990s primarily through the Dutch Research Council (NWO),[55] which operates under the Ministry of Education, Culture, and Science.[56] Through NWO, the government funds both fundamental and applied research, thereby strengthening research capacity in ethics and technology over the past decades and providing valuable support for studies in the field.

In addition to this structural funding, ministries have at times commissioned research directly from academic and research institutions to address specific ethical concerns in technology and engineering. Although such commissioned research primarily serves policy needs, it can also be seen as an indirect form of support, as it reinforces the role and legitimacy of these institutions. [57]

*Institutional infrastructures:* The ethical and social challenges stemming from technological progress have frequently prompted the Dutch government to contemplate its capacity for systematic investigation, for instance, in dedicated bodies. Kool et al. mentioned four types of these bodies: state commissions, advisory committees, commissions for organizing public debates, and permanent committees.[58]

*Actions against ethical violations:* The Netherlands does not have a nationwide licensing system for engineers comparable to American state boards. Consequently, formal disciplinary mechanisms specifically related to engineering ethics appear to be absent or limited.

#### *4.2.2. The organizational level in the Netherlands*

Most organizations that contributed to the development of ethics and engineering in the Netherlands were founded after World War II, except for a few professional associations that were founded in the early half of the twentieth century. Like in the description of the US, we focus on those organizations that played a significant role in shaping engineering ethics in the Netherlands and distinguish here between funding organizations, academic research centers, and professional associations.

*Funding organizations:* NWO has contributed to the development of specialized centers, such as the Center for Society and Genomics (CSG), established under the Netherlands Genomics Initiative.[59] In some cases, research has also been commissioned directly; for example, in 1990, the Ministry of Education commissioned the Multidisciplinary Center for Church and Society (MCKS) to study ethical codes and their role in technological and scientific professions.[60]

*Academic research centers:* Research activities in engineering ethics have been strengthened by establishing a cooperative research center between the philosophy groups of the three Dutch universities of technology (in Delft, Eindhoven, and Twente) in 2007, later extended with Wageningen University.[61] This center is now Europe's largest engineering ethics research center,[62] and likely the world's.[63] The 4TU. Ethics collaborates with other international research institutions, government organizations, industrial partners, and societal organizations.[64] In addition to academic research centers, government-established institutes have also played a significant role in shaping research and policy in this field. The Rathenau Institute is an advisory body for the parliament on issues related to science, technology, and innovation.

This center started as the Rathenau Commission, established by the Ministry of Education[65] in 1979 to look into the social effects of microelectronics.[66] It focused on the institutionalization of Technology Assessment (TA) in 1986.[67] The Rathenau Institute also played an essential role in the development of engineering ethics education in Dutch universities by recommending reforms to the Higher Education Act to the parliament in 1993.[68]

*Professional associations*: The Netherlands is home to numerous professional engineering associations, such as the Royal Institute of Engineers (KIVI). There are also discipline-specific associations, such as the Royal Dutch Association for Chemistry (KNCV). Founded in 1847, KIVI is the largest professional association for engineers in the Netherlands.[69] After extensive deliberation and a few unsuccessful attempts, KIVI adopted a professional code in 2003. However, there has been no licensing system or other forms of enforcement associated with this code yet. Additionally, KIVI adheres to the Engineers Europe's code of conduct.[70]

In general, engineering ethics in the Netherlands is not driven by demand from professional associations. Although ethical matters have sometimes been discussed within some study groups in the associations, it seems that ethical issues often remain implicit in professional discussions. Brumsen believed that there was a perception that ethical awareness within professional societies was not highly developed at the time.[71] He suggested that factors such as legal considerations, including whistleblowing, and the close ties between professional associations and industry might contribute to many professional associations' cautious stance on ethical issues. Therefore, most Dutch engineers did not even have a code of ethics until the 1990s.

### *4.2.3. External and contextual factors that impacted national engineering ethics in the Netherlands*

To better understand how engineering ethics has evolved in the Netherlands through time, given the historical developments discussed so far, we distinguish between two periods: from the 1970s to the 1990s, and the 2000s onwards.

*Between the 1970s and 1990s, the era of Technology Assessment discourse*: Before the 1970s, engineering ethics in the Netherlands had not yet emerged as a distinct institutionalized field. Ethical reflection mainly concerned the social responsibilities of scientists and engineers in response to external influences such as the use of chemical weapons during World War I, nuclear technology after World War II, and Cold War tensions. These concerns stimulated lectures, publications, and discussions within scientific communities and industrial laboratories such as Philips Physics Laboratory, although economic conditions and shifting priorities often limited continuity.[72]

From the 1970s onward, external influences – such as societal concerns about new technologies – interacted with emerging contextual forces, including institutional developments such as Technology Assessment (TA) and legislative frameworks, which shaped the institutionalization of engineering ethics. New technologies and their application during this time sparked public concerns, which were echoed by scientists and the media.[73] For instance, the Club of Rome's Limits to Growth report[74] profoundly impacted discussions in the Netherlands. This re-evaluation of technology's ambivalence, as noted by Grunwald,[75] triggered a crisis of orientation in science and technology, ultimately motivating the emergence of TA. The government's answer was to create several advisory bodies for legislation and policy-making. As a result, parliament passed numerous rules outlining the acceptable application of new technologies. In terms of education, new social contexts in universities aided the Higher Education Act of 1960 in launching courses on the STS in universities in the 1970s. Then, some factors, including the implementation of the act, considerable institutionalization in the 1970s and 1980s, the spread of discussions on TA, and the ethics boom in the United States, all worked together to build a context for the passage of the new Higher Education Act of 1993.

*The 2000s onwards, the era of Ethics of Technology discourse:* In this later period, developments were primarily shaped by contextual forces within an institutionalized engineering ethics environment. At the beginning of the 2000s, Dutch philosophers shifted the philosophy of technology's approach to technology. The so-called empirical turn in the philosophy of technology shifted attention from abstract reflection on technology to technological practices, engineering design, and concrete technologies, thereby stimulating ethical reflection on technology and supporting the growth of ethical studies in the decade. [76] [77] Van de Poel also discusses the impact of organizational factors on Engineering Ethics development, such as the presence of philosophy faculties in all three technical universities of the Netherlands.[78] These faculties were traditionally focused on the philosophy of technology and engineering, but with the higher education laws of the previous decade and new curricula, they shifted their attention to teaching and research in ethics and the emergence of 4TU, as explained before.

## 5. Comparative analysis

In this section, we conduct a comparative analysis of the US and the Netherlands. In the previous section, the NEE framework was used to provide a systematic understanding of the engineering ethics environment in each country and to identify relevant governmental, organizational, and contextual factors. Our aim in this section is not to compare the engineering ethics environments of the two countries as such, but to compare the development of engineering ethics in those countries. For this reason, the comparative analysis is organized around three guiding questions: why engineering ethics emerged, how it developed over time, and which actors played key roles in this process. The findings from the NEE-based country analyzes provide the empirical basis for answering these questions.

In this section, we examine similarities and differences to provide answers to these three questions, as a basis for identifying the drivers of engineering ethics development.

### *5.1. External triggers for emerging engineering ethics development*

In both countries, major political and social events, such as engineering scandals and the introduction of new technologies, caused concerns among the population and academic community. These concerns also contributed to discussions about technology and societal responsibilities. With some time lag, governments in both countries responded to these concerns. While these developments can be understood as external influences, their impact depended on how they were interpreted within each country's specific institutional context.

An example of such external influences is the use of technology in the Vietnam War and World Wars, and the environmental and consumer movements in the American society, which led to STS studies and, later, to engineering ethics activities. Also, in the Netherlands, the use of chemical and nuclear weapons in World War I and II led to STS studies. Furthermore, the introduction of new technologies in the 1970s led to the TA and ethics of technology. Here, we should not neglect media's role in public awareness and conveying the public's demands to governments. Also, we can point to philosophers of technology who challenged the idea that technology is value-free, as well as to the empirical turn in the philosophy of technology in both countries.[79]

However, there exists a significant difference between the United States and the Netherlands. In the US, major accidents triggered discussions on engineering ethics in the 1970s, leading to a shift in focus towards engineering practices. In contrast, in the Netherlands, the absence of significant accidents and scandals (to the extent we could find in the literature), together with a relatively lower degree of autonomy and power of professional engineering associations, shaped a different trajectory. As a result, ethical studies were more directed toward technology itself rather than the practices of engineers. These differences were also reflected in the role of professional engineering associations, which, although varying over time, were generally more actively involved in shaping discussions on professional conduct in the US, particularly in the earlier stages, than in the Netherlands.

### *5.2. The process of development*

In the Netherlands, the increasing use of technology sparked public concern, which was also expressed by scientists in their lectures and articles. Governments responded to this

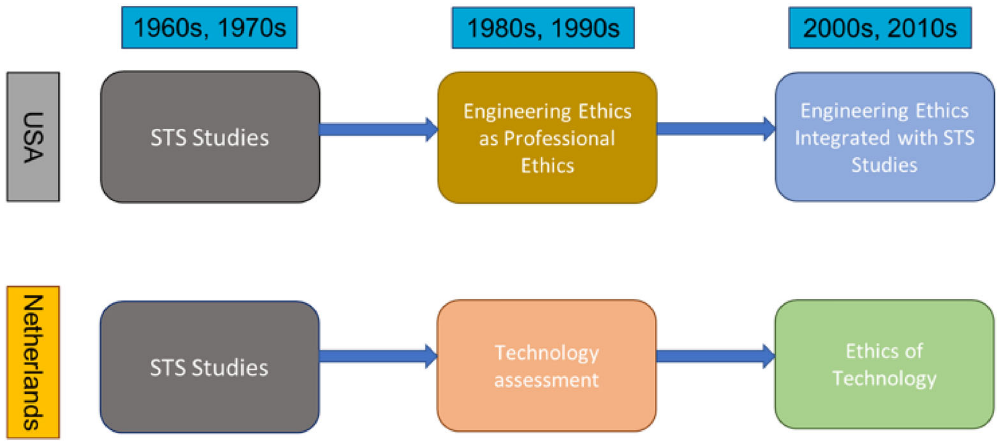


**Figure 2.** Comparing the process of engineering ethics research development.

by establishing advisory committees. Also, bills were drafted, and legislations were passed for research and educational initiatives. These legislations, in combination with the actions of key individuals, contributed significantly to the institutionalization of engineering ethics, both in education and research.

In the US, escalating public concern about technology and engineering practices first prompted individuals to initiate new academic courses and research. Subsequently, educational and research centers – supported by governmental organizations such as the NSF and foundations like the Rockefeller Brothers Fund – conducted novel research and established courses. Professional associations also influenced educational and research initiatives, advocating for the inclusion of engineering courses in curricula during the 1970s and contributing to ABET 2000, which is a set of criteria for accrediting educational programs in engineering in the US requiring attention to engineering ethics. Concerning the professional conduct of engineers, professional societies made efforts to adopt new codes of conduct or revise existing ones from the early 1970s onwards.

There are certain similarities between the processes in both countries. We discuss five here.

First, in both countries, the development of engineering ethics followed a broadly similar institutional pattern: external influences initially triggered ethical reflection, while contextual forces became increasingly important as the engineering ethics environment gradually took shape and became institutionalized over time.

Second, in the years before the 1970s, there were already professional associations in both countries and codes of ethics for engineers. These developments provided an initial framework for more systematic engagement with ethical issues later. While these codes were not established solely for ethical reasons – often also serving to enhance professional status – they nonetheless provided an initial framework for ethical reflection on engineering. Moreover, STS studies fostered greater awareness of technology's social dimensions. This background, even if indirectly, facilitated the emergence of more explicit philosophical and ethical debates on engineering and technology (Figure 2).

Third, the development of engineering ethics in both countries followed a bottom-up process, where individuals initiated the first moves. These individuals were instrumental in defining research projects, securing funding, and persuading professional organizations to prioritize ethics in their activities.

Fourth, engineering ethics education was in both countries one of the first actions that was carried out at the organizational level. The first educational programs were developed by the Hastings Center in 1977 in the United States and by the TU Delft in 1993 in the Netherlands. It is important to note that these initiatives primarily focused on developing individual courses rather than comprehensive degree programs.

Fifth, engineering education accreditation systems in both countries required higher education institutions to instill a sense of social and professional responsibility in their engineering students. In the Netherlands, relevant frameworks include the Higher Education and Scientific Research Act (1992) [80] and FEANI/Engineers Europe accreditation,[81] among others; in the United States, examples include ABET's Criteria for Accrediting Engineering Programs [82] and the America COMPETES Act. In both countries, the legal frameworks lacked explicit mandates to make the teaching of engineering ethics a formal requirement for accreditation. Both laws are generic and general, without providing the necessary power to enforce the inclusion of ethics education in engineering curricula. The ABET 2000 did not offer enough strength to compel universities to offer engineering ethics courses, resulting in many major universities discontinuing these courses. Additionally, the America COMPETES Act did not fully address the need for integrating ethics into graduate-level engineering programs, further limiting its impact. In the Netherlands, the Higher Education Act of 1992 was similarly vague, offering no clear mechanisms for enforcing ethics education.

There are, of course, some differences between these two countries. We discuss five here:

First, in the United States, licensure laws were enacted across all states during the initial decades of the twentieth century. It has been estimated that approximately one-third of American engineers possess an engineering license.[83] In contrast, the Netherlands lacks specific legislation pertaining to engineering licenses, and engineers are not required to hold a license for engineering activities. The enactment of these laws in the US, along with outcomes such as the establishment of the NSPE and actions by state licensure boards, fostered a more conducive environment for developing ethics within the American engineering profession than in the Netherlands. However, the importance of licensing in the US should not be overstated due to issues such as the possibility of practicing engineering without a license, legal difficulties in punishing violators, and the continued ability of offenders to work in other states despite being prohibited in one.

Second, while legislation as a governmental action has been a crucial activity in the Netherlands, in the US, the NSF and foundations' financial support, and also professional societies' actions steered the development of engineering ethics to a large extent.

Third, although the institutionalization of education in the Netherlands began later than in the United States, it occurred more rapidly and thoroughly. For instance, while ABET 2000 considered ethics about 25 years after the emergence of engineering ethics courses, in the Netherlands, the first ethics courses in technology universities emerged immediately after the Higher Education Act of 1993. Indeed, the Netherlands, being a much smaller country, offers more proximity between institutions, making coordination and institutionalization processes more efficient compared to the United States, where both physical and institutional distances between institutions are much greater. Almost all universities in the Netherlands are state-owned, whereas the US has relatively more private universities, which may further slow institutionalization. This aligns with the NEE Framework, where biophysical conditions, such as the size and geographic location of a country, are seen as contextual forces impacting the pace and nature of engineering ethics development.

Fourth, in the US, the developments occurred in both academic and professional environments. Some people argue that professional engineering associations took the first steps toward national engineering ethics in the US, while the contribution of professional organizations was much more limited in the Netherlands.[84]

Fifth, in the Netherlands, the active engagement of Dutch philosophers in engineering ethics is notably more pronounced than in the US,[85] and this difference is reinforced by the collaborative research culture among philosophers within technological universities. Such collaboration has been a prominent feature in the Dutch context, fostering a strong culture of interdisciplinary cooperation, whereas in the US, research in the field tends to be more individualistic, with philosophers often working independently rather than as part of large, interdisciplinary research teams. This difference in research mentality reflects distinct academic and cultural traditions in each country, without necessarily implying a qualitative judgment of one approach over the other.

Examining the disparities discussed above reveals several factors, such as variations in the conception of engineering as a profession,[86] differences in the nature of professional organizations,[87] the relative emphasis placed on organizations rather than professional associations,[88] the presence or absence of national accreditation for engineering education,[89] differences in the requirement of a professional license for engineering practices,[90] divergent roles assigned to professional ethics codes,[91] and distinct philosophical traditions that shape the analysis of technology and engineering.[92] In each of these respects, the two countries have followed different paths, which account for the contrasting trajectories of engineering ethics development.

### *5.3. Actors that played key roles in national engineering ethics development*

At the governmental level, although both countries' governments have contributed to advancing engineering ethics, there are notable differences. Concerning the role of governments in education and research, Dutch authorities demonstrated greater explicit involvement by directly enacting legislation, such as the Higher Education Act of 1993, which required universities to incorporate ethics into engineering curricula. In contrast, in the United States, the federal and state governments relied less on direct legislation and institutionalization, leaving much of the responsibility to non-governmental actors. For instance, the accreditation of engineering education was handled by ABET, a non-governmental organization.

Regarding the role of governments in fostering professional conduct, the Dutch government did not significantly intervene in the development of engineering ethics within professional organizations. In contrast, the United States enacted legislation and controls to ensure engineers' adherence to ethical codes of conduct. For instance, the American government, particularly individual states, played a major role in institutionalizing professional conduct by requiring engineers to hold a license. However, as noted earlier, the actual impact of licensing has been uneven and limited in practice.

Regarding educational organizations, engineering ethics education has been institutionalized in both countries, with universities historically offering courses for engineering students. Yet, despite this shared trajectory, in the US, few universities currently require them, whereas teaching continues steadily in the Netherlands. In contrast, Dutch universities collaborated more by founding the 4TU. Ethics Center. In research, with financial support from organizations such as the NSF and NWO, activities in both countries rose significantly. Although these studies were conducted earlier in the United States, the partnership between research institutions in the Netherlands has been more coordinated. However, it should be noted that current support from some funding bodies in the US, particularly NSF, has diminished compared to earlier periods, partly due to the current political climate. According to Davis, Dutch universities, including TU Delft, provide engineering ethics researchers with a high-quality education, potentially distinguishing them from their American counterparts.[93] Van de Poel identifies the following historical and organizational factors as influential for such a position in research in the Netherlands over a short period: first, a strong tradition in the field of STS and TA; second, the engagement of philosophy departments at the three Dutch technology universities in the philosophy and ethics of technology, including their institutional embedding; and finally, the establishment of the 4TU Center for Ethics and Technology.[94]

Finally, American engineering professional organizations differ from their Dutch counterparts in that they have historically been more powerful and autonomous, though their engagement with engineering ethics has fluctuated over time. Nevertheless, with increasing attention to the ethical dimensions of emerging technologies, professional societies such as IEEE are actively expanding their initiatives, for example, in areas like AI ethics. Instead of professional associations, the primary responsibility for the moral advancement of engineers lies with engineering companies in the Netherlands.

Although governmental and organizational layers were central to shaping engineering ethics, pioneering individuals in both countries played a decisive early role. They worked in environments where many engineers and scientists resisted ethical reflection by appealing to technological neutrality, yet they initiated the first discussions of engineering ethics and often sustained them during periods of limited institutional support. Their backgrounds were diverse – ranging from philosophers, humanities and social science scholars, to engineer–philosophers – which helped establish the field before formal structures emerged. Figures such as Stephen H. Unger in the United States and Jeroen van den Hoven in the Netherlands exemplify how individual agency was crucial in the formative years, even though institutional actors later became more prominent. Nevertheless, the drivers of development extended beyond individual efforts, involving broader systemic and contextual forces.

## 6. Discussion: drivers for institutionalizing NEE

In this study, the term 'drivers' refers to the key commonalities identified as crucial factors in the development and institutionalization of national engineering ethics (NEE). While additional similarities between the two cases could be highlighted, we believe that these selected drivers are more broadly applicable and generalizable to other countries. We classified them into *external influences, contextual forces,* and *the triple helix*.

### 6.1. External influences: challenge-driven triggers and public determinants

Our analysis identified several key external drivers, including engineering events, technological advances, public concerns and demands, and media influence.

In both countries, engineering incidents and technological developments triggered public concern among scientists and the general public. The intensification of these concerns subsequently led to public demands directed at government authorities or professional organizations. Notably, these demands served as catalysts, prompting proactive movements within governmental bodies or professional entities.

Simultaneously, media plays a crucial role in shaping the trajectory of engineering ethics, amplifying and disseminating public concerns and demands. This dynamic interaction between external influences and the ethical landscape underscores the intricate relationship between society, engineering, and the engineering ethics environment. As discussed earlier, external influences (such as engineering incidents and technological developments) and contextual forces (such as institutional arrangements and professional traditions) are analytically distinct but closely interrelated: external influences play a key role in initiating ethical reflection, while contextual forces shape how such influences are interpreted and institutionalized within the engineering ethics environment.

### 6.2. Contextual forces: institutional dynamics and societal attributes

Our comparison of the development of engineering ethics between the Netherlands and the United States indicates that the development of engineering ethics is highly context-dependent, i.e. the institutional environment and the attributes of the society are very influential. The more direct interventions of Dutch governments in forming organizations and committees related to engineering ethics, compared to the reliance of federal and state governments in the US on non-governmental organizations and professional associations, highlight the important role of the institutional environment. Institutional differences also play a significant role in how engineering ethics developed over time in both countries. For example, the autonomy and power of American professional engineering societies have no counterpart in the Netherlands, leading to distinct differences in engineering ethics development in both countries. Likewise, different organizational structures (e.g. centers in the US or committees in the Netherlands) that are rooted in the culture of the country, and even the biophysical characteristics such as the much smaller size of the Netherlands compared to the US, have shaped the pace and manner of institutionalization.

These contextual forces help explain why the two countries, although both leaders in the development of engineering ethics, have followed different pathways in the development of engineering ethics. These differences are, by and large, rooted in contextual forces rather than being conscious choices.

### 6.3. The triple helix: academia, professional associations, and government[95]

The notion of 'triple helix' denotes the synergistic relationship among three essential components: academia, professional associations, and government, highlighting their collective influence in steering the development of engineering ethics at the national level.

In both the Netherlands and the US, academia serves as a fundamental component within the triple helix framework, actively contributing to the theoretical foundations and educational initiatives in engineering ethics. This influence is achieved through integrating ethical considerations into the engineering curricula, fostering research endeavors, and cultivating a culture of integrity among students. The historical trajectory of engineering ethics activities within universities in these two countries reveals a parallel progression. Notably, research and education have not been pursued in isolation but rather as interconnected endeavors, reflecting a commitment to fostering ethical values within the engineering profession.

Professional associations play a pivotal role in the development of engineering ethics by defining ethical codes, providing education to their members, monitoring the conduct of professional engineers, and fostering discussions on ethical challenges through conferences, seminars, and lectures. This engagement is instrumental in shaping the ethical landscape within the engineering profession. In both the Netherlands and the US, a symbiotic relationship exists between engineering societies and universities, with universities collaborating to enhance the ethical standing of professionals. This collaboration extends to the development of ethical codes and the integration of ethical topics into engineering education. Professional associations also engage in consultations with universities to contribute to more effective government policies concerning the engineering profession. The literature highlights the vibrant role of American professional organizations in the development of engineering ethics, establishing close ties with both governments and universities. Conversely, some studies suggest a need for a more substantial role for their Dutch counterparts. At the same time, interviewees and commentators have noted that in the US, professional associations' commitment to ethics has not always been consistent, which has slowed the continuity of ethical development over the decades. This dynamic interplay emphasizes the multifaceted influence of professional associations on engineering ethics development, fostering collaboration across academia, professional bodies, and government entities.

Governments in both countries played a pivotal role within the triple helix as well, legislating research and education, helping to regulate professional behavior in engineering, and monitoring compliance with laws in academia and professional associations. Governments played an important role in advancing engineering ethics, whether through the direct establishment of advisory centers and committees or by creating the conditions for professional associations and non-governmental organizations to operate, often accompanied by financial support. The US experience further suggests that whenever such governmental support has diminished, the forward momentum of these developments has noticeably slowed.

## 7. Conclusion

While engineering ethics is well established in some countries, it remains under development and institutionalization in many others. Therefore, it is important to understand how policies for national engineering ethics can be made more effective. This study has used institutional analysis to analyze and compare the emergence and development of engineering ethics in two leading countries, the Netherlands and the United States. Our aim was to find common drivers that may inform policy recommendations and design strategies for engineering ethics development in different countries.

Based on the similarities between the two countries, the following are proposed as the drivers for developing engineering ethics at the national level: (1) external influences (i.e. factors originating outside engineering ethics, such as challenge-driven triggers and public determinants); (2) contextual forces (i.e. factors within that environment, including institutional dynamics and societal attributes); and (3) the triple helix of academia, professional associations, and government relations.

The important role of external influences and contextual forces in developing and institutionalizing engineering ethics implies that there is no one-size-fits-all solution for the development of engineering ethics in a country. Consequently, countries that want to foster engineering ethics should pay attention to both their specific context and the external influences affecting engineering ethics, rather than just copying the US or Dutch pathways. At the same time, they may seek to strengthen collaboration among academia, professional associations, and government.

## Notes

1. Weil, "Rise of Engineering Ethics."
2. For instance, see Brumsen, "Ethics in Engineering," and Didier, "Engineering Ethics in France."
3. Downey, Lucena, and Mitcham, "Engineering Ethics and Identity."
4. Didier, "Engineering Ethics at Lille."
5. Luegenbiehl, "Ethical Autonomy and Engineering."
6. Dizani et al., "Understanding Engineering Ethics."
7. For instance, see Downey, Lucena, and Mitcham, "Engineering Ethics and Identity."
8. Dizani et al., "Understanding Engineering Ethics."
9. Hess and Fore, "Systematic Review of US Engineering Ethics."
10. Van de Poel, Zandvoort, and Brumsen, "Ethics and Engineering Courses."
11. Dizani et al., "Understanding Engineering Ethics."
12. Ostrom, *Understanding Institutional Diversity*.
13. Ibid.
14. Weil, "Rise of Engineering Ethics."
15. Most experts were consulted online; one responded via email and another reviewed the manuscript. Their feedback helped ensure the accuracy and relevance of the study.
16. Davis, "Defining 'Engineer'."
17. Spinden, "The Enigma."
18. Federal Acquisition Regulation, 48 CFR § 3.1002 (2023).
19. California Business and Professions Code. § 6730. 2022.
20. Whistleblowing is often seen as illustrating the core tension between engineering professionalism and the obligations engineers face as employees of profit-oriented organizations.
21. Whistle-blowers Protection Act, 5 U.S.C. § 2302(b)(8) (1989).
22. See Wisnioski, Every American an Innovator**.**
23. Texas Board of Professional Engineers, "Enforcement News."
24. In 2025, the NSF cancelled more than a thousand research grants, including several in technology and ethics, following shifts in funding priorities; see Scire, "NSF Cancels Grants," and Schwabish and Axelrod, "NSF Has Canceled."
25. Mitcham and Briggle, "Interaction of Ethics."
26. Baum, *Ethics and Engineering Curricula*.
27. Hollander and Steneck, "Science-and Engineering-Related Ethics."
28. Ibid.
29. Weil, "Rise of Engineering Ethics."
30. Hollander et al., "Remembering Vivian Weil."
31. Hollander and Steneck, "Science- and Engineering-Related Ethics."

32. Weil, “Rise of Engineering Ethics.”
33. Johnson and Wetmore, “STS and Ethics.”
34. Davis, “Ethics Boom,” 172.
35. Baum, *Ethics and Engineering Curricula*.
36. Johnson and Wetmore, “STS and Ethics.”
37. Weil, “Rise of Engineering Ethics.”
38. Baum, *Ethics and Engineering Curricula*.
39. Mitcham and Briggle, “Interaction of Ethics.”
40. Martin and Schinzinger, *Ethics in Engineering*.
41. Zandvoort, Van De Poel, and Brumsen, “Ethics in Engineering Curricula.”
42. Mitcham, “Importance of Philosophy.”
43. Of course, some scientific fields, such as computer ethics, dealt with the ethical dimensions and effects of technology; see O’Connell and Herkert, “Engineering Ethics.”
44. Expansion include greater interaction between engineering ethics and STS, the rise of macro ethical topics, and the addition of ethics of technology. See Johnson and Wetmore, “STS and Ethics”; Herkert, “Future Directions”; and Zandvoort, Van de Poel, and Brumsen, “Ethics in Engineering.”
45. Johnson and Wetmore, “STS and Ethics.”
46. Van de Poel, “Ethiek van de Techniek.”
47. Zwaal, *Geschiedenis van Het Raadgevend*.
48. Kool et al., “Urgent Upgrade.”; Brumsen, “Ethics in Engineering.”
49. Zandvoort, Van de Poel, and Brumsen, “Ethics in Engineering Curricula.”
50. The term "government" is here used in a broader sense, including both government and parliament.
51. Rip and Boeker, “Scientists and Social Responsibility”; we will explain more about this event in the next sections.
52. Rip and Boeker, “Scientists and Social Responsibility”; Zandvoort, VanDePoel, and Brumsen, “Ethics in Engineering Curricula.”
53. Brumsen, “Ethics in Engineering”; Zandvoort, Van de Poel, and Brumsen, “Ethics in Engineering Curricula.”
54. Brumsen, “Ethics in Engineering.”
55. The Nederlandse Organisatie voor Wetenschappelijk Onderzoekthe.
56. For more information, see https://www.nwo.nl/.
57. See Section 4.2.2 for examples at the organizational level.
58. Kool et al., “Urgent Upgrade.”
59. Ibid.
60. Hogenhuis, Beroepscodes En Morele Verantwoordelijkheid.; Brumsen, “Ethics in Engineering.”
61. Van de Poel, “Ethiek van de Techniek.”
62. Didier, “Foreword.”
63. Van de Poel, “Ethiek van de Techniek.”
64. For more information, see https://ethicsandtechnology.eu.
65. Brumsen, “Ethics in Engineering.”
66. Kool et al., “Urgent Upgrade.”
67. Ibid.
68. Brumsen, “Ethics in Engineering”; For more information, see https://www.rathenau.nl/.
69. For more information, see https://www.kivi.nl.
70. Brumsen, “Ethics in Engineering.”
71. Ibid.
72. Rip and Boeker, “Scientists and Social Responsibility.”
73. Kool et al., “Urgent Upgrade.”
74. Meadows et al., *The Limits to Growth*.
75. Grunwald, “Technology Assessment.”
76. Van de Poel, “Ethiek van de Techniek.”
77. Verbeek, “The Empirical Turn.”
78. Van de Poel, “Ethiek van de Techniek.”

79. Achterhuis, *American Philosophy of Technology*; Kroes and Meijers, *Research in the Philosophy of Technology*.
80. Overheid, Wet op het Hoger Onderwijs.
81. Brumsen, "Ethics in Engineering."
82. ABET, "Criteria for Accrediting."
83. See McGuirt, "The Professional Engineering Century."
84. Brumsen, "Ethics in Engineering."
85. Mitcham and Wang attribute this exceptional involvement to the critical role of engineers in the country's maintenance and the well-developed state of STS Studies within the Dutch context; see Mitcham and Wang, "From Engineering Ethics."
86. Van de Poel, Zandvoort, and Brumsen, "Ethics and Engineering Courses."
87. Brumsen, "Ethics in Engineering."
88. Van de Poel, Zandvoort, and Brumsen, "Ethics and Engineering Courses."
89. Brumsen, "Ethics in Engineering."
90. Ibid.
91. Van de Poel, Zandvoort, and Brumsen, "Ethics and Engineering Courses."
92. Didier, "Foreword."
93. Burgess et al., "Engineering Ethics."
94. Van de Poel, "Ethiek van de Techniek."
95. Triple Helix' originally refers to university–industry–government relations (Etzkowitz & Leydesdorff). Here it is adapted to describe interactions among academia, professional associations, and government.
96. Dizani et al., "Understanding Engineering Ethics."

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## Author contributions

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