



A Systematic Review of the 2016 National Academy of Engineering Exemplary Ethics Programs: Revisions to a Coding Framework

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Abstract

Engineering ethics is a required aspect of accredited ABET programs, but there is widespread variation in how ethics is taught, to what ends, and how those ends are assessed. This variation makes it challenging to identify practices for teaching ethics to engineers aligned with extant practices in the field. In this study, we revise a recent coding framework by reviewing exemplary engineering ethics programs recognized by the National Academy of Engineering in 2016, or what we refer to as “exemplars.” We pursue two primary objectives: (1) To apply and revise a prior coding framework to codify ethics learning objectives, instructional strategies, and assessment strategies in engineering education; and (2) To use the revised coding framework to identify trends in learning objectives, instructional strategies, and assessment strategies of NAE exemplars. We employ systemic review procedures to update the coding framework using 24 of 25 exemplars as a data source. The updated framework includes four primary categories associated with learning objectives, instructional strategies, assessment data collection strategies, and assessment design characteristics. Results indicate that ethical sensitivity or awareness was present in every exemplar as a learning objective, often alongside ethical reasoning-based learning objectives and the formation of professional skills. Exemplars employed numerous instructional strategies in tandem, as we coded eight out of 18 instructional strategies among at least half of the exemplars. Assignments/homework and summative reflections were the most oft-used sources of assessment data. Due to our challenges in coding assessment approaches, we offer practical suggestions for assessing engineering ethics instruction which are based on many of our coding discussions. We hope that this coding framework, the results classifying exemplary features of the NAE programs, and our practical suggestions can guide future instructors as they design, classify, assess, and report their approaches to engineering ethics education.

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Introduction

Ethics is an essential student outcome required for ABET (n.d.) accreditation. Thus, there is a need to identify which approach for teaching ethics to engineering students in post-secondary contexts are considered valuable or effective. The NAE or National Academy of Engineering (2016) recently provided one source of such guidance. In this report, NAE compiled what they deemed 25 “exemplary education activities and programs.” These exemplars provide programs, courses, or activities that one may adopt or modify to their unique contexts. However, approaches to engineering ethics education can vary widely, and this variation can serve as a source of uncertainty regarding what practices instructors should use. In this study, we identify instructional trends across these NAE exemplars to understand their common and exemplary features. We envision that this effort will provide information about what practices are currently being used and help clarify what approaches may be seen as particularly valuable in engineering ethics education.

Multiple forces, such as sociohistorical context (e.g., ABET expectations) and cultures of higher education (e.g., the aims of a university or institution) can influence one’s approach to teaching engineering ethics. Katz (2019) found that contemporary approaches to and perspectives on engineering ethics are informed by numerous considerations, such as individual agency (e.g., to what extent do faculty have the freedom and autonomy to teach ethics in ways that align with their personal values?), structural or systemic factors (e.g., how and to what extent is teaching ethics incentivized by institutional reward structures?), and historical contingencies (e.g., who are engineering ethics “trailblazers” and how do their perspectives shape and guide current practices?). Thus, myriad forces work in tandem to inform one’s approach to teaching ethics.

This study provides a review of a small subset of programs and activities in a complex landscape of engineering ethics education. We recognize that analyzing NAE exemplars alone may appear to exclude other perspectives and practices. Given our dataset, our results describe common aspects of what NAE, and the authors of the exemplars, deemed *exemplary* aspects of engineering ethics education at a single point in time and in a single national context.

Despite the limitation of only focusing on a single NAE report, we seek to situate findings in the larger and growing body of work. Specifically, we juxtapose these findings with those from prior work, especially a recent prior systematic review of engineering ethics interventions in the US (Hess & Fore, 2018). Thus, these findings can help elucidate a more holistic picture of common threads in ways of teaching engineering ethics in the US during the first two decades of the 20th century. Moreover, we frame findings *descriptively*, thus detailing what the exemplars are, rather than *normatively*, or arguing for what exemplary engineering ethics instruction *ought to be*.

Study Overview

The primary objective of this study was to synthesize instructional ethics programs, courses, and activities for engineers featured by the NAE in 2016. Our primary research question was, “What are the instructional features of the 2016 NAE exemplary ethics programs?” To address this research question, we applied, extended, and modified a coding framework for classifying ethics learning objectives, instructional strategies, and assessment strategies (Hess & Fore, 2018). Two sub-objectives guided our investigation: (1) To apply and revise a prior coding framework to codify ethics learning objectives, instructional strategies, and assessment strategies in engineering education; and (2) To use the revised coding framework to identify trends in learning objectives, instructional strategies, and assessment strategies of NAE exemplars. Results enhance the robustness of the previous coding framework and provide insights into the exemplary features of the NAE-recognized program.

The prior coding framework was developed via a systematic review approach and content analysis of 26 peer-reviewed journal articles (Hess & Fore, 2018), whereas the NAE exemplars report represents a curated and edited collection of 25 short papers. We aimed to test the external validity of the prior coding framework by applying it to a different type of publication and enhance the generalization of the framework by applying it to a larger sample size. Despite differences in scope of the data types, the data sources share several important similarities. Both data sources included undergraduate and graduate programming efforts. In addition, the NAE exemplars met the inclusion criteria of the prior review (i.e., explicit learning objectives, instructional strategies, and assessment mechanisms). Thus, the extension of the coding framework with the exemplars provided an opportunity to enhance the coding framework for classifying ways of teaching and assessing engineering ethics in the US.

The reader might ask, “What will I learn from this study that I could not learn by reviewing the NAE report alone?” In short, this manuscript generates a better understanding of the state of engineering ethics education in the United States by applying an existing coding framework to new data. This extension of the framework will enable us (i.e., the engineering ethics education community) to better understand where we have collectively been, which (in turn) can support the improvement of future engineering ethics education efforts.

Our study has two notable limitations that we wish to emphasize with readers from the outset.

First, the understanding that we develop is descriptive in nature and reveals commonalities and differences across NAE exemplars. While we do not address any hypotheses in this work, the patterns we find across exemplars can help future engineering educators introduce ethics into their courses and curriculum with greater confidence that they are in alignment with prior efforts. Other instructors may find motivation to build on the work of particularly unique exemplars. Yet other scholars may use our analysis to identify gaps in current approaches and to move the field of engineering ethics education in new directions.

Second, we reviewed two-page reports but two-pages is likely insufficient space for one to comprehensively describe their education efforts. Our analysis is then limited to what exemplars could articulate in light of such a constraint. While reviewing

data collected directly from NAE authors (e.g., interviews) would have yielded distinct results, we chose to retain a sole focus on the two-page texts as we felt that what authors emphasized in the reports are likely to be what they deemed most valuable (or perhaps most “exemplary”) to share with external audiences.

Background

What is Engineering Ethics?

A review of engineering ethics education must first discuss how to define engineering ethics. In a 1980 Hastings Center report, Callahan (1980) recognized that teaching ethics is fraught with contention and disagreement regarding what ethics is and how it should be taught. Nonetheless, Callahan argued that we can find “rough agreement on the domain and subject matter of ethics” (p. 62). Moreover, as Katz (2019) found, engineering faculty members’ views of what constitutes ethics plays an influential role in their course learning objectives and approaches. Thus, it is important to address this foundational question before identifying how best to teach ethics.

We conceive of ethics broadly as a response to the question, “How ought one live?” This is a political question, too, and connects to a broader question, “How should we live together?” (D. E. Hess & McAvoy, 2014, p. 4) In engineering, these questions might become more specific as we instead ask, “How ought one practice engineering?” For example, some definitions of “engineering ethics” focus on the standards and expectations of engineering practice (Davis & Feinerman, 2012). For the purposes of this study, we adopt a broader stance, and further conjecture that any decisions that one makes, be it ‘inside’ or ‘outside’ of engineering education or practice, have ethical implications and can influence how one may practice engineering.

While the NAE did not require that exemplars explicitly define ethics, the organizers of the report prioritized ways of conceiving of ethics through submission criteria. For example, the NAE indicated that submissions must “connect ethics to technical engineering content.” Hence, the NAE explicitly expected exemplars to explicate ethical-technical connections. This framing is notable, as many faculty mental models see ethics as something that can be learned outside of the engineering context, or what Katz (2019) described as “outsourcing” (e.g., teaching ethics in a philosophy course alone). In addition, the NAE selection committee required that authors address micro-ethical concerns (e.g., ethics in individual interactions, individual ethical actions) and/or macro-ethical concerns (e.g., considerations of societal issues of engineering practice, collective decision-making). Herkert (2005) offers additional insights regarding this micro/macro distinction.

In this study, we do not synthesize definitions of ethics, but rather we presume that all exemplars’ instructional approaches, particularly their learning objectives, offer responses to the question, “How ought one practice ethical engineering?”

What are Common Engineering Ethics Learning Goals, Objectives, or Outcomes?

There are numerous aims of engineering ethics instruction. ABET (2000) criteria are an oft-cited guide. Beginning in 2000, ABET introduced an explicit ethics student outcome: “an understanding of professional and ethical responsibility.” In 2016, ABET revised this outcome to: “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.” Hence, ABET shifted from foci on understanding and responsibility alone by adding judgment *and* specific considerations that students ought to account for while making ethical judgments in engineering (i.e., global, economic, environmental, societal).

Before ABET EC2000, Harris et al. (1996) argued that multiple learning goals were important for engineering ethics, channeling suggestions directly from a 1980 Hastings report (Callahan, 1980). Examples of important learning goals included striving to stimulate students’ “ethical imagination,” “help students recognize ethical issues,” “help students analyze ethical concepts and principles that are relevant to the particular profession or practice,” and to “help students deal with ethical disagreement, ambiguity, and vagueness” (p. 94). The list of goals identified by Harris et al. (1996) is not exhaustive but showcases variety in instructional goals for engineering ethics instruction. More recently, Davis and Feinerman (2012) described four common learning goals:

When we speak of teaching ethics, we mean at least one of the following: (a) improving ethical sensitivity (the ability to recognize problems covered by the relevant standards), (b) increasing ethical knowledge (appropriate terms, relevant standards, related institutional practices, such as “hot lines”, decision procedures, and other ethical resources), (c) enhancing ethical judgment (the ability to make competent choices of the appropriate sort for the appropriate reasons more often than chance or common sense), and (d) reinforcing ethical commitment (the likelihood that students will act on what they have learned). (Davis & Feinerman, 2012, p. 352)

Hess and Fore (2018) extended these prior works as they analyzed 26 US. engineering ethics interventions¹ situated in US post-secondary contexts and identified three common types of ethics learning goals: (1) ethical sensitivity or awareness; (2) ethical judgment, decision-making, or imagination; and (3) ethical courage, confidence, or commitment. This list omits *ethics knowledge* emphasized by Davis and Feinerman (2012) and slightly broadens what Davis and Feinerman described as sensitivity, judgment, and commitment. Moreover, Hess and Fore’s (2018) goal one (i.e., sensitivity or awareness) aligns with the ABET EC2000 ethics outcome, whereas both goal one (i.e., sensitivity or awareness) and goal two (i.e., judgment, decision-

¹ The authors required that retained literature included at least one explicitly defined learning goal or objective, sufficient clarity when describing an instructional strategy for it to be replicable, and some form of assessment.

making, or imagination) align with ABET's (n.d.) recently revised ethics outcome. Hess and Fore (2018) found relatively limited interventions explicitly focused on learning goal three, which also aligns with the relative lack of concerted attention on such affective-related learning outcomes in ABET (including EC2000 and recent revisions) and the notable challenge of assessing these types of learning goals (see Davis & Feinerman, 2012).

In the current study, we began with this three-part framing but remained open to adjusting nomenclature and adding learning goals inductively in our review of the NAE exemplars. While we incorporated the above framing, we also recognized there are many other extant frameworks for classifying learning goals, as depicted by Martin et al. (2021a).

What are Common Engineering Ethics Instructional Strategies?

In the US, there are several oft-used instructional approaches to teach engineering ethics. Herkert (2000) stated, "The pedagogical framework of engineering ethics education has evolved primarily toward utilization of case studies and codes of ethics, in some instances supplemented by an introduction to moral theory" (p. 303). Haws (2001) corroborated this in a synthesis of 42 ASEE articles published between 1996 and 1999, wherein Haws identified six prominent instructional approaches to teaching engineering ethics: (1) codes of ethics, (2) humanist readings, (3) theoretical grounding or moral theory, (4) ethics heuristics, (5) case studies, and (6) service learning.

Nearly 20 years later, the review by Hess and Fore (2018) supported both Haws's (2001) and Herkert's (2000) findings. In this review, they identified that codes of ethics and case studies were the most common instructional strategies in the US, and this trend has also been found elsewhere, such as in Ireland (Martin et al., 2021b). Hess and Fore (2018) also identified other, less common approaches, including some identified by Haws. For example, philosophical ethics (or what Haws called theoretical grounding) and community-engagement (which relates to what Haws called service-learning) appeared in 42% and 8% of articles, respectively. Other codes from Hess and Fore's list included heuristics, discussion or debate, individual written assignments, team projects or papers, presentations, peer mentoring, developing heuristics, developing a case study, micro-insertion, real-world exposure, developing a code of ethics, and playing a game.

While we have listed common instructional strategies above, we wish to emphasize that how faculty members conceive of ethics plays a pivotal role in how they teach ethics and to what ends (Katz, 2019). In other words, instructors are likely to prioritize certain instructional strategies and learning goals based on their beliefs about engineering ethics, including views of *when* students ought to learn engineering ethics, *where* students ought to learn engineering ethics, *who* ought to teach engineering ethics, and *how* students come to learn engineering ethics.

What are Common Engineering Ethics Assessment Strategies?

Like learning objectives, there is a wide variation of assessment approaches used in engineering ethics interventions. Assessment seeks to provide evidence of student learning and (generally) guides formative improvements in instruction to improve learner experiences. Evaluation is related to assessment but is often more summative in nature and may focus on aspects beyond student learning (e.g., identifying the number of students who participated in an intervention). Parker et al. (2001) suggested that the purpose of assessment is “to improve future performance” whereas the purpose of evaluation is “to judge the merit or worth of a performance against a pre-defined standard” (p. T3A-2). We use the term *assessment* through the remainder of the manuscript for alignment with the language prioritized in the NAE report.²

In this study, we differentiate between two primary characteristics of assessment: (1) data collection methods and (2) design characteristics. The former speaks to the type of data that one collects, whereas the latter speaks to procedures for designing the overall methodology, albeit, with an emphasis on analyzing data appropriately.

With regards to data collection, there are not standardized assessment measures to assess ethics learning goals. This is perhaps due to the numerous and multiplicity of learning goals in engineering ethics education (Martin et al., 2021a). Scholars often use *ethical reasoning* instruments such as the DIT2 or Defining Issues Test-2 (Rest et al., 1999), Engineering and Science Issues Test (Borenstein et al., 2010), and Engineering Ethical Reasoning Inventory (Zhu et al., 2014). Canney and Bielefeldt (2016) created an Engineering Professional Responsibility Assessment (EPRA) that provides a measure of students’ social responsibility attitudes. Using these instruments provides instructors with rigorously vetted measures with robust validity evidence and allows for comparison across studies and contexts.

While these measures can provide validated tools to measure specific learning goals (e.g., ethical reasoning in the DIT2, perceptions of social responsibility in the EPRA), one’s learning goals may not directly align with the constructs these instruments measure. Davis and Feinerman (2012) discussed three practical limits of assessment, including the challenges associated with the use of existing assessments (such as the DIT2):

A standardized test of sensitivity or knowledge has to be general enough to provide information about ethics learned in any graduate engineering course (or at least most of them). But it also has to be specific enough to provide information that is useful for assessing a particular class’s small-scale contribution to ethical sensitivity and knowledge. Even asking about the Code of Ethics of the National Society of Professional Engineers (NSPE), though relatively general, is not general enough for a graduate course in Computer Design where the IEEE Code of Ethics would be more appropriate. (Davis & Feinerman, 2012, p. 357)

² While we use the term assessment, many authors used *both* assessment and evaluation. Moreover, we recognize that many assessment strategies were both formative and summative in nature.

Thus, pre-established instruments may not provide evidence aligned with instructors' specific learning goals or objectives. Moreover, Davis and Feinerman (2012) discussed challenges with using extant instruments directly off-the-shelf, such as *time* and *relevance*. In regards to time, Davis and Feinerman (2012) noted that a pre/post test would require up to four hours to implement, which may be unfeasible in some instructional contexts. As they wrote, "The faculty we had recruited for the project refused to take that much time from the substance of their course. They [the engineering faculty] had too much technical material to cover" (p. 356). The second concern was *relevance* – faculty members in their study questioned the alignment of assessments with course goals and expectations.

There are many approaches to assessment that are qualitative in nature, and these afford greater flexibility in the development or iteration of data collection and analysis procedures. Yet, Hess and Fore (2018) code assessment approaches based on their quantitative and qualitative nature and found limited use of qualitative procedures. They highlighted the work of Hashemian and Loui (2010) due to their creative qualitative approach to assessment (these authors interviewed three distinct groups of students and compared responses).

Instructors may deploy assessment approaches designed by others, but we also encourage them to design their own data collection and analysis procedures or modify existing procedures to (1) overcome challenges, such as those listed by Davis and Feinerman (2012), (2) ensure alignment with course learning goals, and (3) ensure applicability to their specific population. When encountering such challenges and seeking to modify existing assessments, instructors may focus on the principles offered by Douglas et al. (2016) to ensure the validity, reliability, and overall robustness of their assessment strategies. These authors provided an analysis of assessment design studies in engineering education, and offered aspects of reliability, fairness, and validation that instructors ought to consider when developing assessments. As they stated, "Assessment instruments need to be designed for very specific purposes and it would not be appropriate to recommend one 'right' method" (p. 1967). They offered a list of questions instructors ought to consider for designing high-quality assessments based on assessment content, substance, structure, reliability, fairness, and use. We return to these considerations in the closing of this manuscript and offer recommendations for engineering ethics education in light of their framework.

Overview of Exemplars

We provide an overview of the NAE exemplars to contextualize results and to share details on the process of becoming an exemplar. Prospective exemplars submitted a two-page proposal to NAE, and these proposals were reviewed by experts in engineering ethics. The NAE review committee accepted 25 proposals from 44 submissions. Thus, the NAE report is not exhaustive of all approaches to engineering ethics instruction in the USA. The process for becoming an exemplar involved peer review and the NAE report includes a complete list of reviewers. Figure 1 provides the assessment criteria that the committee used to review exemplars.

In assessing the submissions the members of the selection committee looked for the following characteristics:

- Provides an interactive format that encourages active learning
- Occurs across multiple years of a student's education
- Includes an institutional faculty reward structure that supports ethics training
- Connects students' ethics learning to engineering practice
- Promotes improved ethical decision-making and problem-solving skills
- Addresses macroethics (the broader ethical and social issues that call for the collective response of the engineering profession and societal decisions about technology), microethics (ethical issues involving the interactions and individual actions of engineers in research and practice), or both⁴
- Incorporates innovative or creative educational methods
- Has a demonstrated widespread or lasting impact on students
- Can be scaled up or easily replicated at other institutions

The 25 selected programs were picked because they clearly exhibit at least one and typically several of these features. The committee also considered the variety of educational approaches and topics covered. The exemplars presented in the following pages encompass a range of program types—undergraduate and graduate courses, multiyear programs, extracurricular experiences—and institutions to illustrate the diversity of effective approaches to infusing ethics into engineering education.

Fig. 1 Assessment Criteria of NAE Exemplars - from National Academy of Engineering (2016), p.1

While we summarize exemplars here and synthesize the instructional approaches of exemplars in this study, interested readers can review the NAE report for additional context. Our analysis summarizes commonalities across the exemplars, and while understanding commonalities is not sufficient to identify best practices for engineering ethics instruction, this analysis can help instructors understand which strategies are oft-used. This understanding can, in turn, boost instructors' self-efficacy regarding teaching ethics in ways aligned with exemplars in the field.

Most commonly, exemplars depicted an entire course ($n=10$, 42%). A third ($n=8$) of the exemplars described parts of a course or activities that could be embedded within course activities, such as the workshop by Eggelson & Dempsey (2016) and training for a summer research program by Loui (2016). Finally, six ($n=6$, 25%) of the exemplars described multiple courses. Appendix A summarizes these distinctions by exemplar, and we employ these three categories when reporting results. While we would not describe any exemplar as “extra-curricular” or “co-curricular,” multiple exemplars leveraged out-of-course experiences, including co-operative learning (Grossenbacher, 2016; Subbian et al., 2016), volunteering (Subbian et al., 2016), and learning communities (Leydens et al., 2016).

Most exemplars focused on efforts at a single institution. Three exemplars focused on efforts across institutions, including Eggelson and Dempsey (2016) who offered a workshop offered to students and faculty across institutions, Loui (2016) who described sessions that were part of a summer undergraduate research program, and Lambrinidou et al. (2016) whose effort included a partnership with a local non-profit organization. Two exemplars depicted pedagogical materials that instructors could utilize in courses rather than a specific course context, including Brightman et al. (2016) who described interactive modules for engineering instructors and Hanks et al. (2016) who described two modular courses developed via an academic/industry partnership. In coding, we omitted one exemplar as the focus was on engineering instructors rather than students (i.e., Litzinger et al., 2016).

Most exemplars were from different universities, although there were seven exceptions. Three exemplars were from Colorado School of Mines but each depicted different efforts, including a course on Corporate Social Responsibility (Smith, 2016),

a course on Nature and Human Values (Hitt et al., 2016), and a multi-year and multi-course initiative focused on macro-ethics (Leydens et al., 2016). Two exemplars were from Massachusetts Institute of Technology, where one exemplar described a course on engineering for safety (Leveson, 2016) and the other focused on a learning community for first-year students (Epstein et al., 2016). Finally, two exemplars were from Northeastern University, including one that described case studies focused on product life cycle (Eckelman et al., 2016) and another that described the integration of case studies across a civil engineering program (Saulnier et al., 2016).

Every exemplar included engineering students, but a variety of engineering disciplines were the foci of individual exemplars. Multiple exemplars included non-engineering students. Likewise, authors were often from engineering, but many authors were outside of engineering.

Half of the exemplars indicated that the learning experience depicted in their work was required for students as part of a university program or, in one instance, students' summer experience (Loui, 2016). For some exemplars, the program/course/activity was required for a subset of students but not all. In other instances, students were required to participate in a subset of the activities, such as humanitarian engineering students who needed to participate in humanitarian engineering courses described by Leydens et al. (2016). Thus, some exemplars included captive audiences; others ostensibly included students interested in ethics or, at the very least, a particular topic covered by the program/course/activity; and yet others had both captive and non-captive students. We were not able to discern whether students were participating in activities as a requirement or an elective for all exemplars.

Finally, most exemplars did not specify whether their effort was in-person, online, or hybrid in nature. Two exemplars emphasized the hybrid nature of their programming (Brightman et al., 2016; Hanks et al., 2016) and one emphasized its online programming (Starrett, 2016). We cautiously infer that all other exemplars were in-person, but it is likely that many of these exemplars leveraged multimedia and online materials and thus had hybrid-like characteristics.

Methodology

For this study, we followed an 11-step systematic review process that built on Borrego et al.'s (2014) procedures, which included:

1. **Reviewing** current literature and ultimately deciding to conduct a systematic review.
2. **Defining** the research questions and sub-questions.
3. **Scoping** the research study, which includes identifying target literature or "data".
4. **Cataloguing** or accessing/importing data to the database.
5. **Exploring** or reading each article, identifying alignment with an existing coding framework, revising existing codes, and creating new codes as needed.
6. **Coding** or applying coding framework to articles.
7. **Checking** or comparing codes across multiple coders.

8. **Finalizing** or coming to complete agreement on coding disagreements across coders.
9. **Quantizing** or calculating descriptive statistics of codes (e.g., frequency, percentage).
10. **Interpreting** or making meaning from the quantified qualitative data.
11. **Narrating** or reporting key findings, key examples from the data, and limitations.

The Step 1 decision to pursue a review of the NAE exemplars arose during a conversation among the authors considering how to extend the prior coding framework. As the coding framework did not include any NAE exemplars³, the NAE report provided a viable opportunity to expand the coding framework. We felt that this expansion would lead to a more thorough understanding of approaches to teaching engineering ethics in post-secondary contexts. While the prior review included 26 full journal articles, the NAE report consisted of two-page synopses of 25 ethics programs. Moreover, in alignment with the inclusion criteria from the prior review, the exemplars primarily describe programs, courses, and activities focused on undergraduate and graduate students.

Step 2 involved defining the research questions. In this study, we addressed the research question: “What are the instructional features of the 2016 NAE exemplary ethics programs?”

In Step 3, we reviewed the exemplars and we omitted one of the 25 exemplars due to its focus on faculty development. Beyond the 1–2 pages of text, most exemplars provided references which included additional instructional resources or scholarly publications resulting from their work. During analysis, we decided to only review such references provided by exemplars *as needed*, such as when we required more clarity on a concept or strategy mentioned in the NAE text. Thus, our coding might best represent what authors conceived as the *exemplary features* of their programs. Moreover, the NAE organizing committee’s selection criteria (see Fig. 1) likely influenced what language and framing authors incorporated into their text, as well as features they may have omitted.

Step 4 involved compiling the literature into a database. We utilized a shared spreadsheet mechanism to facilitate coding across the authors. In Step 5, we explored exemplars by reviewing, coding, and discussing codes using a prior coding framework as a guide (Hess & Fore, 2018). In Step 6, we coded exemplars after solidifying a revised coding framework. Throughout the coding process, the authors met to discuss disagreements and to modify existing codes for greater clarity and consistency across coders. In Step 7, via checking, authors individually reviewed the existing codes. When authors were alone in coding, they added notes to substantiate their position or, when appropriate, modified their code. Finally, we added Step 8 (which is unique from Hess & Fore, 2018) wherein we discussed outstanding disagreements until we reached complete agreement among all authors on the coding. We engaged in Steps 5, 6, 7, and 8 in a sequential but iterative manner, starting with instructional

³ While the NAE exemplars included a few studies from universities represented in the prior literature review, the programs or interventions were distinct. Thus, this dataset is completely unique, and these results thus provide insights into exemplary features of ethics programs.

strategies, transitioning to learning objectives, and closing with assessment. These steps were also deductive (i.e., we applied a prior coding framework), inductive (i.e., we generated new codes), and axial (i.e., we revisited earlier exemplars when we developed new codes or modified prior codes). Finally, to enhance our confidence in coding, at least three authors were involved in coding each category (Authors 1, 3, and 4 coded learning objectives; Authors 1, 2, and 3 coded instructional strategies; and all authors coded assessment approaches).

Step 9 involved tabulating the descriptive statistics for the modified set of codes (see Table 1). Since we modified the coding structure, we do not compare descriptive statistics with the prior review. Nonetheless, we describe differences between the exemplars and the prior review at length in the ‘Discussion’ section. Finally, Steps 10 and 11 involved interpreting and narrating the results.

Study Limitations

Our coding process required interpretation and thus was a subjective process. For example, when coding for learning objectives, authors generally did not explicitly use terms aligned with our codes, such as “sensitivity,” “judgment,” or “professional skills.” We also experienced several noteworthy challenges. For example, when coding assessments, we originally specified the nature of homework-based activities (e.g., written or verbal, individual or group, performance-based or perception-based), but due to challenges in developing consensus on coding these items across all coders, in our final taxonomy we merged these features into a single code, “assignments or homework.” This resulted in less precision regarding what types of assignments instructors administered, but it enabled us to develop unanimous agreement among coders for all exemplars. Despite the interpretive nature of coding and challenges such as this, through our collaborative coding process, we developed confidence in our codes. We also realized the import of emphasizing the challenges and associated limitations of our coding; we thus describe pertinent challenges as we report results.

We emphasize that our codes represent *what authors deemed exemplary* about their effort. Thus, authors may have pursued additional learning goals, instructional strategies, or assessment efforts beyond what they indicated in the NAE report. While we referenced resources provided by authors when we needed clarification, we did not comprehensively code additional resources. For example, several exemplars provided syllabi and we reviewed these syllabi to understand details of an aspect mentioned in the NAE report. Yet, when reviewing syllabi, we did not search for new codes. As a result, our findings highlight the *exemplary* features of the 2016 NAE exemplars and are not necessarily exhaustive of all aspects of exemplars’ instruction, especially multi-course exemplars who likely did not have sufficient space to share to share all of their instructional efforts in two pages.

Finally, ethics instruction is a global activity. This study focuses on exemplars in one national context – the US. Reviews of pedagogical efforts in other nations have been documented, such as the use of case studies in Ireland (Martin et al., 2021b), the development of ethics initiatives in science and technical programs in China (Wang & Yan, 2019), and comparisons of student views on ethics across countries, such as

Malaysia and Japan (Balakrishnan et al., 2019). The findings of this study cannot be generalized to national contexts beyond the US.

Results

The final coding framework (Table 1) included four categories: (1) learning goals or objectives; (2) instructional strategies; (3) assessment – data source or collection method; and (4) assessment – design characteristics. In total, these categories contained 37 binary codes. Table 1 presents an overview of the categories and the binary codes associated with each category. We provide more detailed definitions of these codes, including their relative frequency and examples, in the subsequent sections.

Student Learning Goals or Objectives

All exemplars offered learning goals, learning objectives, or related language. We found that the three types of learning goals offered by Hess and Fore (2018) required slight modification for greater applicability to the exemplars. The primary shift was away from “courage, confidence, and commitment” to “ethical dispositions.” In addition, we added one new learning goal: professional skills. We list the updated goals and their pervasiveness among NAE exemplars in Table 2 and unpack each in more detail below.

Ethical sensitivity or awareness goals aimed to enhance students’ awareness of ethically problematic situations or enhance their sensitivity to ethical issues that they may encounter in the future. While coding exemplars, we realized a prominent focus on cultivating an awareness of macro-ethical considerations, such as the “social” context or social impacts of engineering practice. While this was a common example among exemplars, this is but one example among many aspects of ethical awareness which instructors directed students’ attention. Other examples including drawing attention to general ethical issues, problems, or dilemmas (e.g., Eggleston & Dempsey, 2016; Grossenbacher, 2016; Loui, 2016; Subbian et al., 2016), specific professional issues or considerations (e.g., Pinkus, 2016; Subbian et al., 2016), ethical values (e.g., Boudreau et al., 2016; Troesch, 2016), ethical principles or theories (e.g., Brightman et al., 2016; Hitt et al., 2016), contexts (e.g., Kirkman, 2016; Lambrinidou et al., 2016), the relationship between science, technology, and society (Johnson & UVA STS Program Faculty, 2016), or global awareness (Jackson et al., 2016). We coded ethical sensitivity or awareness as a learning goal or objective in every exemplar (24/24 or 100%).

Ethical judgment, decision-making, or imagination learning goals aimed to prepare students to reason ethically, balance ethical criteria, or imagine different ethical possibilities. This type of learning goal is primarily cognitive, like sensitivity or awareness, but here focuses on tools or techniques that students may use to make ethical decisions or how they might best react when encountering ethical challenges or issues. While some exemplars featured the use of engineering ethics codes or ethical theory to make such decisions, others emphasized processes of engaging others, such as local community members (Lambrinidou et al., 2016), and yet others emphasized

Table 1 Coding Framework (Note that the order of codes aligns with the presentation order in later sections)

Category	Code
1. Learning Goals or Objectives	Ethical sensitivity or awareness Ethical judgment, decision-making, or imagination Ethical dispositions Professional skills
2. Instructional Strategies	Written assignment(s) Case study(ies) Exposure to tools, processes, heuristics Sociotechnical integration Exposure to theoretical or philosophical ethics Discussion or debate Real-world engagement Lecture Codes of ethics Project Presentation Conducting research Receiving mentoring Developing codes of ethics or related standards Developing tools, processes, or heuristics Developing case study Role-play or simulation Peer mentoring
3. Assessment - Data Source or Data Collection Methods	Assignments or homework Summative reflections Distal student outcomes Interviews or focus groups Anecdotal or informal student feedback External evaluation Distal institutional outcomes Participation Examination Psychometric instrument
4. Assessment – Design Characteristics	Descriptive statistics Rubrics Pre/post testing Comparative Qualitative analysis approach

the utility of engineering decision-making processes for ethical decision-making, such as Life-Cycle Analysis (Eckelman et al., 2016). We coded this learning goal in over half of the exemplars (13/24 or 54%), including 75% Activity-type exemplars, 50% of the single Course exemplars, and 33% of the multi-course exemplars (see Table 2). Thus, Activity-type exemplars were more likely to identify this learning goal when compared to the other types.

Table 2 Learning Goals or Objectives (Note that the order of codes aligns with their discussion in later sections)

Code	Description	Overall (n=24)		Activ- ity (n=8)		Course (n=10)		Cours- es (n=6)	
		n	%	n	%	n	%	n	%
Ethical sensitivity or awareness	To enhance students' awareness of ethically problematic situations or enhance their sensitivity to ethical issues that they may encounter in the future.	24	100	8	100	10	100	6	100
Ethical judgement, decision-making, or imagination	To prepare students to reason ethically, balance ethical criteria, or imagine different ethical possibilities.	13	54	6	75	5	50	2	33
Ethical dispositions	To enhance students' ethical dispositions, thus preparing them to act ethically.	3	13	1	13	2	20	0	0
Professional skills	To focus on professional skills that connect to one or multiple of the above learning goals.	10	42	3	38	3	30	4	67

Ethical dispositions learning goals aimed to bolster students' desire, motivation, or commitment to acting ethically. Exemplars focused on the development of a commitment to normative principles (e.g., fairness) or on students' motivation to act ethically in their future careers. Example dispositions included conscience (Biezad, 2016), confidence (Starrett, 2016), commitment (Starrett, 2016), and care (Hariharan et al., 2016). We coded this type of learning goal in only a few exemplars (3/24 or 13%), including one Activity-type exemplar and two single Course exemplars (see Table 2).

Professional skills learning goals focused on professional skills that connect to one or multiple of the above learning goals, thus providing students with tools to act ethically, make ethical judgments, or become aware of ethical issues. Examples included teamwork or collaboration skills (Boudreau et al., 2016; Epstein et al., 2016; Grossenbacher, 2016; Hanks et al., 2016; Kirkman, 2016), writing and communication skills (Boudreau et al., 2016; Hitt et al., 2016; Johnson & UVA STS Program Faculty, 2016; Kirkman, 2016; Lambrinidou et al., 2016), and leadership (Jackson et al., 2016). We coded this type of learning goal in over a third of the exemplars (10/24 or 42%), including 3 of 8 Activity-type exemplars, 3 of 10 single Course exemplars, and 4 of 6 multi-course exemplars. Thus, multi-course exemplars were more likely to feature professional skills when compared to the other types of exemplars.

Importantly, we only coded learning goals or objectives when they were listed by the NAE authors as goals or objectives. However, some exemplars reported student *outcomes* which they did not explicitly describe as learning goals. For example, Troesch (2016) stated:

The two principal education goals of my class are for students to (1) recognize the values embodied in the professional code of ethics for engineering and understand how these values influence actual personal and professional ethical decision making, and (2) have an understanding of their professional and ethical responsibilities. (Troesch, 2016, p. 24)

We coded this text as ethical sensitivity or awareness alone, due to Troesch's (2016) emphasis on recognition and understanding but *not* application. However, Troesch (2016) later wrote, "On completion, my students are affectively engaged in their work and demonstrate improved ethical reasoning skills and understanding of their professional and ethical responsibilities" (p. 25). While the *educational goals* align with sensitivity or awareness, these *outcomes* align with ethical judgment, decision-making, or imagination and potentially even ethical dispositions. Yet, because this was not explicitly identified in the authors' goals and objectives, we only coded ethical sensitivity or awareness in this instance.

A similar example occurred with Hanks et al. (2016) who wrote, "After completing this course, students will understand [...] how to work in a group and conduct systematic research to write a group-based term paper on case studies and/or research topic" (p. 42). As working in a group was an outcome of the course but not an explicit goal, we did not code "professional skills" in this instance.

Several NAE exemplars focused on *program objectives* separate from, but (ostensibly) in relation to student learning goals. We did not code program objectives in this study, but we revisit such considerations in the assessment text as some exemplars depicted *program outcomes* as a data source.

Instructional Strategies

We developed 18 codes associated with instructional strategies. Table 3 provides the codes along with a brief description of each. The table lists codes by order of frequency. In addition, the table includes frequency counts by type of exemplar (e.g., Activity, Course, Courses) and the relative percentage of the instructional strategies overall and by type. Six of these instructional strategies were present in more than half of the exemplars, two appeared in exactly half of the exemplars, and the remaining were present in less than half.

Written assignments were the most pervasive type of instructional strategy (n=20, 83%); case studies were the second most common instructional strategy (n=17, 71%); the third most common instructional strategy was exposure to tools, processes, or heuristics (n=16, 67%); fourth, we coded sociotechnical integration in 15 (63%) instances; fifth, 14 (58%) exemplars mentioned the use of discussion or debate as part of the program, course, or activity; and sixth, exposure to theoretical or philosophical ethics appeared in 14 exemplars (58%).

Of the 12 subsequent instructional strategies, two were found in half of the exemplars and the remaining 10 strategies were described in less than half of the exemplars. These strategies included real-world engagement (n=12, 50%), lecture (n=12, 50%), codes of ethics (n=11, 46%), projects (n=11, 46%), presentations (n=10, 42%), conducting research (n=8, 33%), receiving mentoring (n=6, 25%), developing codes or guidelines (n=5, 21%), developing tools, processes, or heuristics (n=4, 17%), developing a case study (n=4, 17%), role-play or simulation (n=2, 8%), and peer mentoring (n=1, 4%). We recognize that exemplars likely used some of these strategies in their programs, courses, or activities but did not emphasize these in their one to two pages of text. For example, lecture likely occurred in most, if not all, exemplars.

Table 3 Instructional Strategies

Code	Description	Overall (<i>n</i> = 24)		Activ- ity (<i>n</i> = 8)		Course (<i>n</i> = 10)		Cours- es (<i>n</i> = 6)	
		<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Written assignment(s)	As a team or individually, any writing assignment of any length that is connected to learning goals	20	83	5	63	10	100	5	83
Case study(ies)	Engaging with ethical case studies.	17	71	7	88	7	70	3	50
Exposure to tools, processes, heuristics	Reviewing/applying ethical reasoning processes, tools, or techniques.	16	67	6	75	6	60	4	67
Sociotechnical integration	Integrating ethical/social issues into or alongside technical or engineering content	15	63	5	63	4	40	6	100
Exposure to theoretical or philosophical ethics	Engaging with philosophical ethics or ethical theories	14	58	5	63	7	70	2	33
Discussion or debate	Discussing ethics among peers as part of the program/course/activity	14	58	5	63	7	70	2	33
Real-world engagement	Any interactions or engagement with practitioners or community members	12	50	2	25	7	70	3	50
Lecture	In-class content, lectures, or presentations of concepts or materials.	12	50	4	50	5	50	3	50
Codes of ethics	Reviewing codes of ethics	11	46	4	50	5	50	2	33
Project	As a team or individually, writing a paper or engaging in a project that features an ethics component.	11	46	3	38	4	40	4	67
Presentation	As a team or individually, presenting research, case study, or a position on an ethics topic	10	42	1	13	6	60	3	50
Conducting research	Conducting research explicitly on ethics or exploring ethical issues as part of a research project.	8	33	1	13	4	40	3	50
Receiving mentoring	Receiving explicit mentorship from others (e.g., peers, faculty members)	6	25	1	13	4	40	1	17
Developing codes of ethics or related standards	Developing or reflecting on codes or related standards for ethical practice, such as a code of ethics, rules, standards, or values	5	21	0	-	5	50	0	-
Developing tools, processes, or heuristics	Developing or reflecting on one's own ethical tools, processes, or heuristics	4	17	0	-	3	30	1	17
Developing case study	Developing an ethical case study, potentially for use within one's own program	4	17	1	13	2	20	1	17
Role-play or simulation	Any form of acting as a character (e.g., within a case study, simulation activities, games)	2	8	1	13	1	10	0	0
Peer mentoring	Coaching or leading peers in ethics-related activities; providing critical peer feedback.	1	4	0	0	1	10	0	0

When we account for type of exemplar, we find several notable differences. All multi-Course exemplars included sociotechnical integration compared to 63% of Activity-type exemplars and 40% of single Course exemplars. Single Course exemplars were the only type of exemplar that tasked students to develop codes of ethics. Single Courses were more likely to emphasize real-world engagement when compared to multiple Course-type and Activity-type exemplars (70% versus 50% and 25%, respectively). Finally, single Course exemplars and multi-Course exemplars courses were much more likely to involve presentations when compared to Activity-type exemplars (60%, 50%, versus 13%).

Despite the above differences, one item remains consistent when we look across exemplar types – each described and combined several instructional strategies. On average, exemplars that depicted Activities included 6.4 instructional strategies; exemplars that depicted a Course included 8.8 instructional strategies; and exemplars that depicted multiple Courses included an average of 7.2 instructional strategies. Thus, this combinatorial approach to instruction seems to be a defining feature of the exemplars regardless of type.

Assessment Strategies

While learning goals and instructional strategies included one primary category, we divided assessment into two sub-categories focused on data collection approach and design characteristics (Tables 4 and 5, respectively).

Assessment – Data Collection Method

The first assessment sub-category (Data Collection) summarizes the types of data that exemplars collected and used to provide evidence of student learning or, in some instances, to indicate the exemplary nature of the program, course, or activity. Table 4 provides a summary of codes by order of pervasiveness. Two codes occurred in over half of the exemplars (assignments or homework; reflections on individual learning or program efficacy), one code occurred in a third of exemplars (distal student outcomes), and the remaining codes occurred in four or less exemplars (i.e., less than 20% of exemplars).

The most common data collected was assignments or homework ($n=19$, 79%). The pervasiveness of this code suggests that exemplars often capitalized on at least one instructional strategy to provide evidence of student learning. Many exemplars collected written data, such as through reflective writing (Subbian et al., 2016), journal entries (Hariharan et al., 2016), essays (Biezad, 2016; Boudreau et al., 2016; Smith, 2016; Troesch, 2016), project reports (Biezad, 2016; Hitt et al., 2016; Leveson, 2016), final papers (Leydens et al., 2016), theses (Johnson & UVA STS Program Faculty, 2016), and miscellaneous case study activities or analyses (Beever & Brightman, 2016; Eckelman et al., 2016; Loui, 2016). Others collected observational data through student presentations, such as student posters (Johnson & UVA STS Program Faculty, 2016), formal presentations (Smith, 2016), or a public defense (Epstein et al., 2016). Multiple exemplars used both written and verbal sources of data (e.g., Johnson & UVA STS Program Faculty, 2016; Pinkus, 2016; Smith, 2016). We ini-

Table 4 Assessment Strategies – Data Collection Methods

Code	Description	Overall (<i>n</i> = 24)		Activ- ity (<i>n</i> = 8)		Course (<i>n</i> = 10)		Cours- es (<i>n</i> = 6)	
		<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Assignments or homework	Any formal program/course/activity assignment. These data may be associated with an instructional strategy (e.g., written assignments, presentations).	19	79	6	75	8	80	5	83
Summative reflections	Students' open-ended or closed-ended responses on learning gains associated with a program/course/activity, specifically, or the efficacy of an intervention, generally. Students may reflect via formal course evaluations, formal assessments created specifically for the program or activity, or informal mechanisms.	15	63	5	63	5	50	5	83
Distal student outcomes	Outcomes that manifest over extended periods of time, such as graduation rates, retention rates, and program/activity enrollment, but other examples include unique things alumni do following the program/activity, such as teaching ethics, mentoring peers, or participating in scholarly events.	8	33	0	-	4	40	4	67
Interviews or focus groups	Narrative accounts of individual learning or perceptions of the program which also afforded opportunity for just-in-time follow-up questions (unlike reflections).	4	17	2	25	0	-	2	33
Anecdotal or informal student feedback	Informal or unsolicited feedback, such as through e-mail comments, verbal statements, or non-formal program/course/activity observations.	4	17	0	0	3	30	1	17
External evaluation	Engaging someone external to a program/course/activity in data collection (e.g., program reviewer, industry professional, or faculty colleague)	4	17	2	25	0		2	33
Distal institutional outcomes	This code draws attention to outcomes or incidental benefits that the exemplar has had at an institution (e.g., a radio station to share learning with the public; grant funding). This type of evidence does not focus specifically on students, although the outcomes may influence or enhance student learning opportunities.	3	13	0	-	2	20	1	17
Participation	Use of participation as a proxy for student learning <i>or</i> as an element of a grade.	3	13	0	-	3	30	0	-
Examination	End of program/course/activity examination, which may include tests or quiz.	3	13	0	-	2	20	1	17
Psychometric instrument	This code indicates use of a well-established psychometric instrument (exemplars' employed instruments to measure ethical reasoning, specifically).	2	8	1	13	1	10	0	-

Table 5 Assessment– Design Characteristics

Code	Description	Overall (<i>n</i> = 24)		Activity (<i>n</i> = 8)		Course (<i>n</i> = 10)		Courses (<i>n</i> = 6)	
		<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Descriptive statistics	Providing a quantitative summary of results by reporting mean, standard deviation, frequency, or other numerical data.	11	46	4	50	4	40	3	50
Rubrics	Applying select criteria to score or quantify students' qualitative responses on written or verbal and individual or group assignments	10	42	5	62.5	3	30	2	33
Pre/post testing	Comparing pre/post responses of students (i.e., before/after program/activity)	9	38	5	62.5	3	30	1	17
Comparative	Comparing results by groups or by comparing intervention types	5	21	1	12.5	3	30	1	17
Qualitative analysis approach	Using a purposeful and systematic approach to identify themes, categories, or related insights from assessment data	4	17	1	12.5	2	20	1	17

tially sought to code for individual versus group-based activities, but we found it challenging to confidently code for this distinction.

The second most common strategy was summative reflections (*n* = 15, 63%), which found students reflecting on individual learning resulting from the program/course/activity or, more generally, reflecting on its efficacy. While exemplars may have assigned written reflections to students, if written reflections were primarily summative (i.e., reflecting on learning), we only coded them here (e.g., Eggleston & Dempsey, 2016). As with the assignments code, summative reflections varied. Most notably, some summative reflections prompted students to consider their personal growth, others emphasized program efficacy, and some emphasized both. For example, Starrett (2016) used an IDEA short form to prompt student ratings of the course, but also asked students to reflect on their progress towards the learning objective of “developing a clearer understanding of, and commitment to, personal values” (p. 4). Efficacy considerations included satisfaction, engagement, or related considerations about the general effectiveness of the program/course/activity for promoting learning. For example, Biezd (2016) stated, “Surveys before and after the class showed that engineering students appreciated and benefited from the historical mathematical and philosophical focus on ethics, and they fully appreciated the significant ethical challenges they will encounter” (p. 20). Summative reflections were sometimes in the form of formalized course evaluations (e.g., Leveson, 2016) but often involved summative reflection prompts designed by the instructors (e.g., Lambrinidou et al., 2016; Rossmann, 2016). As these examples show, the summative reflections were qualitative (e.g., open-ended) or quantitative (e.g., selecting from a prescribed list of options), but some authors prompted both response types.

We created two distal codes: distal student outcomes and distal institutional outcomes. Examples of distal student outcomes include shifts in course enrollment over time (Hanks et al., 2016; Leveson, 2016), application of course learning in later courses (Smith, 2016), service/leadership activities of program alumni (Epstein et al., 2016), students receiving awards (Johnson & UVA STS Program Faculty, 2016),

or alumni's achievement on the Fundamentals of Engineering Exam (Saulnier et al., 2016). Examples of distal institutional outcomes include the development of new courses at an institution (Smith, 2016), novel news or media mechanisms (Epstein et al., 2016), grant funding (Smith, 2016), or other shifts in institutional culture (Leydens et al., 2016). Returning to the assessment/evaluation distinction we presented in the 'Background' section, these distal codes tended to be more evaluative in nature (i.e., program-evaluation-oriented) as opposed to assessing students' attainment of learning goals or outcomes (Parker et al., 2001).

Assignments were the most common data collection approach for each type (e.g., Activities, single Course, multiple Courses). Multiple Courses were much more likely to describe distal student outcomes when compared to single Courses or Activities (67% versus 40% and 0%, respectively). Summative reflections were more common among multiple Courses when compared to exemplars that primarily featured Activities and Courses (83% versus 63% and 50%, respectively). Participation was only collected as data in single Courses, and single Courses did not describe using interviews as data. Finally, like the results associated with instructional strategies, each type of exemplar used a similar number of data collection approaches. On average, Activity-type exemplars described collecting 2.0 data collection approaches, single Course exemplars described 2.8 data collection approaches, and multi-Course exemplars described 3.5 data collection approaches. Thus, the longer duration exemplars reported collecting more assessment data.

Assessment – Design Characteristics

This category captures exemplars' approaches to analyzing and presenting results of assessment data. Table 5 provides a summary of the five codes associated with this category.

The two most common approaches were the use of descriptive statistics ($n=11$, 46%) and rubrics ($n=10$, 42%). Over a third of exemplars employed pre/post testing ($n=5$, 21%), five used another form of comparative testing ($n=5$, 21%), and four used a formalized qualitative analysis approach ($n=4$, 17%). While distinct, these codes sometimes occurred in tandem. For example, exemplars sometimes used rubrics to quantify students' qualitative responses and then described those results via descriptive statistics.

We coded descriptive statistics in 11 instances. Most often, authors referred to mean or average responses (e.g., Boudreau et al., 2016; Eggleston & Dempsey, 2016; Rossmann, 2016; Starrett, 2016; Troesch, 2016), but some authors also reported frequencies or percentage responses (Hanks et al., 2016; Lambrinidou et al., 2016; Leydens et al., 2016). We recognized after coding that this number seemed low. We posit that the primary reason for this is that many authors described assessment outputs in terms of general findings but did not report specific data. For example, Brightman et al. (2016) suggested that students experienced "significant increases in their ethical reasoning levels" (p. 40). Due to this language, we coded pre/post but we did *not* code descriptive statistics due to no explicit statistics shared or the explicit use of statistic-like terminology (e.g., mean, average).

Exemplars often created their own rubrics to ensure alignment with learning goals. For example, Hitt et al. (2016) designed a Nature and Human Value's (NHV) assessment rubric, Pinkus (2016) developed an "innovative assessment grid that includes five higher methods of moral reasoning" (p. 6), Johnson and UVA STS Program Faculty (2016) developed a rubric to assess ABET criteria, and multiple authors developed rubrics to assess student responses to case studies (Brightman et al., 2016; Loui, 2016). While these self-created rubrics established criteria and ranked student responses to select criteria, Hariharan et al. (2016) used a slightly distinct method to establish students' "global preparedness" via a "Global Preparedness Ratio," which they computed by noting "resolved and unresolved discontinuity events" in student reflections (p. 31). In addition to self-created rubrics, some exemplars extended existing rubrics, such as Eckelman et al. (2016) who extended the Association of American Colleges and University (n.d.) ethical reasoning VALUE rubric. As these examples indicate, authors generally used rubrics to assess assignments (see assignments data collection code above). With a few exceptions (e.g., Loui, 2016), authors generally did not report the descriptive statistics resulting from applying rubrics, which is why we coded descriptive statistics less often than expected. Importantly, we did not code uses of "psychometric instruments" as rubrics, although we recognize that psychometrics tend to use rubric-like methods to summarize findings.

Comparative analyses manifested in various ways. We initially developed this code with quasi-experimental controlled research designs in mind, but no exemplars used the term "control" in this sense. Instead, multiple authors explicitly and purposefully compared results (we omitted potential but non-purposeful comparisons, such as observations of course progress over time). The five times we coded comparative testing were all distinct. Starrett (2016) compared results to an IDEA measure with other published uses of the instrument; Troesch (2016) compared DIT2 results with "normative standards"; Hitt et al. (2016) compared responses across different years of a course offering; Saulnier et al. (2016) compared student success on a Fundamentals of Engineering Exam with a national sample; and Loui (2016) used a counterbalanced design to compare student responses to two different cases within a single summer program. While some of these comparison approaches involved juxtaposing findings with external groups, the cross-year and counterbalance designs offered modalities for comparing results internally at a single university or course.

Four authors used purposeful or systematic approaches to analyzing qualitative data. Unlike rubrics, these analyses did not assess student responses based on prescribed criteria. Like comparative analyses, each instance that we coded "qualitative analysis approach" revealed distinct approaches to qualitative analysis. Lambrinidou et al. (2016) employed a thematic analysis approach; Boudreau et al. (2016) used textual analysis to evaluate student portfolios and reflective writing samples; Troesch (2016) used a "qualitative philosophical hermeneutic approach (which looks for evidence of understanding) to assess whether my students expressed an understanding of their professional and ethical responsibility in their final essays" (p. 25); and Leydens et al. (2016) used a grounded theory approach.

When we account for variation by type of exemplar, on average, single Course exemplars described more assessment design characteristics than Activities-type exemplars and multi-course exemplars (2.8 versus 2.0 and 1.33, respectively). Nota-

bly, Activities-type exemplars were much more likely to utilize rubrics and pre/post testing when compared to Course and multi-course exemplars. (i.e., 62.5% versus 30% and 33%, respectively). Activity-type exemplars applied pre/post-testing at a greater rate than a Course or Courses (62.5% versus 30% and 17%, respectively). Three exemplars did not report assessment design characteristics.

Discussion

In this study, we implemented and revised a prior coding framework for classifying instructional strategies used in US ethics education efforts in engineering (Hess & Fore, 2018). The prior study synthesized 26 articles published between 2000 and 2018 from four journals. The dataset here was comprised of 24 instructional programs (activities, courses, or multi-course sequences) which were featured in the 2016 National Academy of Engineering (NAE) Report, *Infusing ethics into the development of engineers*. We first revised the coding framework for greater applicability to the exemplars and then summarized the frequency of instructional strategies among exemplars. In this discussion, we consider prominent characteristics of these engineering ethics programs and how these compare with other modes of ethics instruction in engineering in the US. Thus, this discussion provides a more exhaustive representation of approaches to teaching ethics in US engineering post-secondary contexts.

We consider learning goals, instructional strategies, and assessment strategies in turn. Throughout these three sub-sections, we (1) summarize the codes associated with each category, (2) identify exemplary features using the coding framework, and (3) compare codes with prior reviews of US instruction. Thereafter, we discuss implications for teaching and recommend directions for future research.

Learning Goals

We coded four learning goals: (1) ethical sensitivity or awareness, (2) ethical judgment, decision-making, or imagination, (3) ethical dispositions, and (4) professional skills. While the first three codes were in the prior review, we added a new code in this analysis – professional skills – which we applied in nearly half of the exemplars (42%).

Every NAE exemplar sought to cultivate students' ethical sensitivity or awareness. Moreover, these types of learning goals were present in nearly every article in the review by Hess & Fore (i.e., 96%). This indicates that these types of learning goals serve as a baseline for ethics instruction in engineering. We did not focus on sub-dimensions of ethical sensitivity but recognize this as one viable direction for future research. For example, future research might ask, "What aspects of (engineering) ethics should students be aware of or sensitive to?" Addressing these questions would bring greater clarity to how we conceptualize ethics or, more specifically, which aspects of ethics we agree students should be aware of or sensitized to. For example, Celik et al. (2020) defined ethics in terms of privacy, fairness, responsibility. For them, ethics was separate from but related to sustainability and collabora-

tion. Thus, we encourage instructors to employ the category of ethical sensitivity or awareness and be precise regarding targeted ethical considerations, stakeholders, or other concepts that they hope their students will become aware of.

More than half (54%) of the exemplars sought to cultivate students' ethical judgment, decision-making, or moral imagination. We found that this code was more pervasive in the prior review (i.e., 89% in Hess & Fore, 2018). This may suggest that exemplars were less likely (at least explicitly) to prioritize cognitive-based reasoning modalities. Alternatively, the nature of data in the two studies may have led to this differences, such as the need for robust research methods in many journal publications (which was not a requirement of the NAE exemplars) and the common use of ethical-reasoning based instruments in engineering ethics research endeavors.

Martin et al. (2021a) offered 12 learning goals for engineering education research, and our tripartite grouping encompasses multiple categories which Martin et al. separate. Thus, our coding of learning goals and objectives may be too parsimonious. Moreover, others may group learning goals in different ways. For example, Clarkeburn (2002) suggested that ethical sensitivity is comprised of moral imagination and recognition of ethical issues. Like Clarkeburn, we agree that the two inform each other, although we grouped imagination with recognition due to its focus on "an ability to foresee moral consequences of an action" (p. 440). Future research might further synthesize and discern the interconnection between ethical sensitivity, awareness, judgment, decision-making, and moral imagination.

Few exemplars explicitly emphasized ethical dispositions as learning goals or objectives. The examples we observed manifested as conscience (Biezad, 2016), confidence (Starrett, 2016), commitment (Starrett, 2016), and care (Hariharan et al., 2016). This is not to say that authors did not prioritize or recognize the import of ethical dispositions, as many exemplars described the import of attitudes, values, motivations, and beliefs (which are components of the affective domain of Bloom's taxonomy). We posit that the limited appearance of dispositions may be partially due to the lack of emphasis among such goals by ABET and the challenge of assessing these types of learning goals (Davis & Feinerman, 2012).

Professional skills manifested in various ways, with foci on other ABET outcomes such as teamwork and communication. The pervasiveness of this class of learning goals among exemplars suggests that authors deemed these professional skills as integral to engineering ethics education (albeit we recognize that these goals are similarly important to other aspects of engineering education, such as design and teamwork). As one example, Lambrinidou et al. (2016) emphasized the importance of engaging and listening to individuals in the local community to develop a more holistic ethical sensitivity among students. We posit that such professional skills play an important role in each of the aforementioned learning goals, with – potentially – an increasingly pronounced role in ethical sensitivity, ethical judgement, and ethical dispositions, respectively. Future research ought to explicitly focus on the relationship between professional skills and other ethics-specific learning objectives.

Instructional Strategies

We developed 18 codes associated with instructional strategies, and we coded eight of these 18 instructional strategies in at least half of the NAE exemplars. By order of coding prevalence, these included (1) written assignments, (2) case studies, (3) exposure to tools, processes, or heuristics, (4) sociotechnical integration, (5) exposure to theoretical or philosophical ethics, (6) discussion or debate, (7) real-world engagement, and (8) lecture. Unlike Hess and Fore (2018), we did not further sub-code any of these strategies, primarily due to the brevity of submissions which did not afford more in-depth coding. As one example, written assignments could have been individual or team-based, and they may have been end-of-semester reports or continuous activities woven across a curriculum. Likewise, we did not apply a more in-depth case taxonomy (e.g., Huff & Frey, 2005; Martin et al., 2021b). Similarly, few exemplars concertedly focused on essential features of discussion, but some exemplars emphasized communication-related skills. We think these findings support the need to think more critically as a community about how instructional strategies ought to be delivered to ensure they promote student learning.

We added several new codes. The first was sociotechnical integration, which drew student attention to the specific sociotechnical considerations of engineering. The ubiquity of this code suggests that a defining feature of exemplars was drawing student attention to sociotechnical considerations and their import in engineering ethics.⁴ A second new code was lecture which we coded in half of the articles. Like other codes, it is possible that lecture was not explicitly mentioned by many exemplars; however, it is also possible that a defining emphasis of exemplars is a commitment to non-lecture based activities, which was explicitly prioritized via the “UnLecture” at the University of Cincinnati by Subbian et al. (2016). Third, we created a new code, “receiving mentoring,” which focused on students’ reception of mentoring from others. This code was distinct from the prior peer mentoring code, which focused on students providing mentorship to other students. Lastly, we added a role-play/simulation code, which emphasized students taking on the role of actors during ethical encounters.

Many codes were more common among exemplars when compared to a prior review, such as written assignments (83% versus 54%)⁵, exposure to tools, processes, or heuristics (67% versus 46%)⁶, exposure to theoretical or philosophical ethics (58% versus 42%), real world-engagement (50% versus 12%)⁷, and presentations (42% versus 27%). Importantly, our application of these codes involved slight revisions,

⁴ The prominence of sociotechnical integration in our review could also be because it was prioritized by the NAE solicitation and the selection committee.

⁵ In the prior review, this code was framed as “individual written assignment,” whereas here we broadened to individual or team-based. Thus, it is possible that these numbers are closer in proximity.

⁶ This code was generally used to capture stepwise ethical reasoning processes in the prior review. Yet, here we saw more instantiations of singular tools or processes (e.g., cost-benefit analysis, listening) for making ethical decisions.

⁷ In this study, ‘real-world engagement’ encapsulates two codes from the prior review: (1) real-world exposure and (2) community engagement. In the prior review, these were each coded twice, but one article included both codes. Thus, these articles were coded in 3/26 articles analyzed in the prior review, or 12%.

and these numerical comparisons are not exact (see footnotes for specific differences between the two coding frameworks).

While many instructional strategies were more common among exemplars than articles in the prior review, there were exceptions. Most notably, whereas Hess and Fore (2018) identified codes of ethics in 85% of the articles that they reviewed, less than half of the NAE exemplars incorporated codes of ethics. As instructors historically have used codes in engineering instruction (Haws, 2001; Herkert, 2005), this finding came as a surprise. One potential reason for this finding is that codes were not an innovative aspect of these programs and thus, even when/if implemented by authors, they may not have emphasized their use of codes. On the other hand, some exemplars may have felt that codes of ethics (particularly in isolation) are insufficient for teaching ethics. This sentiment was explicitly expressed by Lambrinidou et al. (2016) who wrote, “L2L [Learning to Listen] challenges the notion that comprehension of moral codes, theories, and principles alone equips engineers to determine what constitutes ‘ethical’ professional conduct in different contexts” (p. 7).

In addition to identifying unique features of exemplary ethics programs, these revisions provide a more thorough overview of instructional strategies used in ethics instruction in the US. Moreover, the codes that were more common among exemplars provide defining features of the programs that the NAE deemed “exemplary” approaches to ethics instruction in the US as of 2016. Lastly, NAE exemplars tended to employ more approaches in tandem when compared with the articles in the prior review, thus suggesting that another defining feature of the NAE exemplars was their combinatorial approach to engineering ethics instruction.

Assessment Strategies

We employed two assessment categories: data collection approach and design characteristics. First, we coded ten data collection methods: (1) Assignments or homework, (2) Summative reflections, (3) Distal student outcomes, (4) Interviews or focus groups, (5) Anecdotal or informal student feedback, (6) External evaluation, (7) Distal institutional outcomes, (8) Participation, (9) Examination, and (10) Psychometric instrumentation. Second, we coded five design characteristics: (1) Descriptive statistics, (2) Rubrics, (3) Pre/post testing, (4) Comparative, and (5) Qualitative analysis approach. These two categories differed from Hess and Fore (2018), who categorized assessments based on quantitative or qualitative emphasis.⁸ While we separated these assessment categories in the results of this study, to facilitate comparisons with the prior review, we discuss both assessment categories in tandem here.

Our categories differed from Hess and Fore (2018), but many of our codes were similar, thus affording comparisons. We found two primary distinctions between NAE exemplars and the Hess and Fore (2018) review. First, NAE exemplars often relied on assignments or homework (75%) as a primary data source. In contrast, Hess and Fore (2018) identified “homework analysis” to be employed in only a few

⁸ One primary reason for this shift may be the nature of the data in two studies. Journal articles might lend themselves to a more intensive analysis of a singular dataset, whereas the exemplars tended to share a broad overview of multiple assessment approaches.

articles (12%). Second, comparative assessment designs were more common in the prior review compared to the NAE exemplars (50% versus 21%). These differences are likely due to the nature of the data (i.e., peer-reviewed articles in Hess & Fore versus 2-page exemplars that required reporting on assessment results).

Exemplars often employed summative reflections (63%) as a primary data source, which were similar in kind and frequency to the codes of quantitative “student perceptions” (73%) and qualitative “course evaluations” (46%) from Hess and Fore. Other frequencies between the NAE exemplars and the previous review included pre/post testing (38% versus 31%), interviews or focus groups (17% versus 15%), and psychometric instruments (8% and 12%). We found the limited presence of psychometric instruments surprising. We posit that this lack of use connects to challenges recognized by Davis and Feinerman (2012), including the recognition that psychometric instruments may not be perfectly applicable to capture specific learning goals and they can be lengthy to deploy.

Finally, we close by emphasizing our coding of distal student outcomes and distal program outcomes. During our coding process, distal student outcomes evolved over time and eventually encapsulated codes that, at one point during the coding process, we named alumni activities and institutional outcomes. This coding evolution also led to the development of the separate (but related) distal program outcomes code. In this final form, both distal codes emphasize evaluative considerations; that is, they do not necessarily provide evidence of student learning. Nonetheless, these seemed to be powerful indicators of programmatic growth, they often helped exemplars receive external funding, or they may have facilitated other auxiliary outcomes. Thus, we offer distal and incidental outcomes as a more concerted consideration for identifying the impacts resultant from engineering ethics interventions in the future. Such considerations might draw attention to how ethics interventions improve the culture of a program or institution.

Implications for Teaching

While our results are descriptive, we feel that we can make reasonable inferences regarding primary implications for teaching based on our experiences and challenges in designing, updating, and applying this framework to the dataset.

Implication 1: Clarify and categorize instructional strategies based on extant taxonomies or frameworks for engineering ethics instruction. The updated taxonomy provides accessible language for engineering ethics educators. We hope this effort can facilitate shared vocabulary for engineering ethics education research and teaching. We faced many challenges in applying the prior framework to this dataset, as indicated above, but with that said, we also found much of the language from a prior taxonomy applicable in this study. The final codes and categories involved incremental (rather than radical) changes. Instructors can use the revised coding framework presented in this study to (1) identify new instructional approaches for their classrooms, (2) determine whether their current approaches are aligned with existing strategies, or (3) justify the innovativeness of their instructional approaches relative to others in the field. Despite these successes, we anticipate that the framework will require additional iterations when applied to new datasets.

Implication 2: Combine instructional strategies to promote student learning.

Teaching ethics using a combinatorial approach and thinking about combinatorial impacts was a defining feature of the exemplars. Regardless of exemplar-type, exemplars combined and utilized multiple instructional strategies to realize learning objectives. Moreover, instructional strategies were not siloed but were generally intended to simultaneously foster engineering skills, including communication and teamwork but also technical skills (e.g., Life Cycle Analysis) and through sociotechnical integration. Thus, instructors seeking to replicate the exemplary ethics approaches recognized by NAE might, similarly, embed and combine multiple instructional strategies with a concerted emphasis on avoiding sociotechnical dualism.

Implication 3: Target professional skills learning goals alongside ethics. Targeting the development of engineering students' professional skills alongside their ethical formation was common among exemplars. Professional skills seemed critical to develop alongside more traditional ethics' learning goals and outcomes. Thus, efforts targeted at teamwork and communication may also incidentally inform students' ethical formation irrespective of instructional intent. We suggest that instructors intentionally foster ethical formation alongside other professional skills in their teaching.

Recommendations for Future Research

First, future work ought to focus on further detailing sub-codes, offering distinct codes where needed, and providing strategies for clarifying information so others may follow suit to replicate engineering ethics instructional approaches. There was widespread variation in instructional strategies that made it challenging to finalize the coding framework at the level of depth we initially sought, which also led to interpretive and interrater challenges. For example, our summative reflections code encapsulates (and, thus, did not differentiate between) distinctions in one's learning and one's overall perceptions of a course. While we initially developed codes to capture these sentiments separately, in our final coding framework, we opted to merge these sentiments into a single code based on our perception that course/program/activity evaluations (generally) prompt one to consider how the experience influenced their learning. Our broadened focus in instances such as these enabled us to come to unanimous inter-coder agreement. We encourage others to employ, expand, and bring greater specificity to these codes in future use, as we recognize that many learning objectives and strategies may be more specific than those we have included here. As one example, while all exemplars sought ethical sensitivity or awareness, what instructors intended to prompt student awareness and sensitivity towards varied. Thus, future work can help verify if our codes are practically useful, where additional specificity is necessary, and whether the framework is missing important instructional features.

Second, there exist many innovative ethical interventions in engineering across the US and across the globe that we did not synthesize in this work. Our study provides insights into strategies featured in a single report. Our study is limited by the cultural and epistemic values that guide engineering ethics instruction in the US, as well as the values of the National Academy of Engineering, especially the committee

and reviewers of the NAE report. Future work applying the framework ought to seek to identify (mis)alignment between this framework and instructional strategies in other US organizations and other national contexts.

Finally, we considered triangulating assessment and learning goals, which would have enabled us to infer the extent to which exemplars' assessment strategies connected to and provided robust evidence of the stated learning goals. We opted not to pursue this line of investigation, noting that the two-page limitations posed a barrier for such specificity. Nonetheless, we think the challenges we experienced whilst coding highlights the need for a more concerted focus on what constitutes appropriate design and reporting of assessment outcomes in engineering ethics education. We offer six quality considerations to guide authors' design and reporting of their assessments. The quality considerations we list are grounded in the framework by Douglas et al. (2016), but this list is *not* exhaustive of all assessment considerations noted by these authors. We thus encourage readers to review Douglas et al. for additional considerations. These suggestions are specifically grounded in and intended to offset challenges we experienced while applying our coding framework, and thus provide guidance for the reporting of assessment approaches and findings.

- **Seek Content Validity by Specifying Data Collection Approaches:** Describe the types of evidence or data that will be collected to assess learning goals or objectives; Provide a rich description of the assessment evidence when reporting data.
- **Seek Substantive Validity by Elucidating Design Characteristics:** Describe characteristics of your design that you will use to make meaning from data; Indicate their relevance to your specific student sample.
- **Seek Generalizability Validity by Clarifying Relevant Populations:** Identify who can and cannot use this assessment, where can they use it, and if/how it must be adapted for employability in other contexts;
- **Seek External Validity via Purposeful Triangulation:** Collect multiple sources of data and specify how they are used to provide a more thorough understanding of a learning goal or objective;
- **Seek Consequential Validity via Alignment Mapping:** Map the alignment between the outputs of data analysis (e.g., outcomes, constructs) and indicate how they provide evidence of the learning goals or objectives;
- **Seek Fairness by Devoting Appropriate Time:** Given challenges of time (Davis & Feinerman, 2012), ensure students have sufficient time to participate in the assessment activity but also ensure the design is feasible for instructors to analyze and synthesize the data set for prompt formative feedback;

Conclusion

In this paper, we continued the development of a coding framework that instructors, practitioners, and evaluators can employ to design, classify, compare, and understand approaches to engineering ethics education. Our expanded framework provided codes associated with learning goals, instructional strategies, and assessment strat-

egies. Using this framework, we generated insights into the features of the 2016 National Academy of Engineering ethics exemplary programs. The results indicate there are myriad learning goals, instructional strategies, and assessment strategies employed to teach ethics even among NAE exemplars. Ethical sensitivity or awareness was a learning objective in every exemplar, suggesting this learning goal serves as a baseline for ethics instruction in engineering. This is not to suggest that this baseline is sufficient – rather, many exemplars also pursued reasoning-based learning goals and the development of students’ professional skills. We also found that exemplars employed a greater diversity of instructional strategies than articles synthesized in a prior review, as we coded eight out of 18 instructional strategies among at least half of the exemplars. Thus, we encourage instructors to pursue multiple instructional strategies in their teaching endeavors. Finally, we found assignments or homework were the most oft-used source of assessment data among these exemplars, followed closely by summative reflections. As we experienced notable challenges, particularly in the assessment section, we offered recommendations for progressing efforts in engineering ethics education, such as guidance for reporting assessment approaches and findings. We hope that others will employ and refine this coding framework in the future in other contexts, be it another engineering organization, another nation, or a specific discipline.

Appendix A. Overview of Exemplars (*Articles are in the Order by which they Appear in the NAE 2016 Report*)

University	Author(s)	Graduate, Undergraduate, or Other	Title	Duration of Intervention
Kansas State University	Starrett	Graduate	Responsibility of Engineering: Codes and Professionalism (3-hour university course)	Course
University of Pittsburgh	Pinkus	Graduate	Using Student-Authored Case Studies to Teach Bioengineering Ethics	Course
Virginia Tech	Lambrinidou et al.	Undergraduate	Learning to Listen: A Tool for Morally Engaged Engineering Practice	Part of a Course*
Worcester Polytechnic Institute	Boudreau et al.	Undergraduate	Humanitarian Engineering, Past and Present: A Role-Playing First-Year Course	Course
The University of Virginia	Johnson et al.	Undergraduate	The University of Virginia SEAS Senior Thesis: A Culminating Activity	Multiple Courses
Georgia Institute of Technology	Kirkman	Undergraduate	Problem-Based Learning in a Professional Ethics Course for Undergraduate Engineering Students	Course

University	Author(s)	Graduate, Undergraduate, or Other	Title	Duration of Intervention
Northeastern University	Eckelman et al.	Undergraduate	Case Studies for Engineering Ethics Across the Product Life Cycle	Part of a Course*
University of Cincinnati	Subbian, Purdy, & Beyette	Undergraduate	UnLecture on Software Engineering Ethics	Course
Massachusetts Institute of Technology 1	Leveson	Graduate and Undergraduate	Ethics and Engineering for Safety – <i>a semester-long class</i>	Course
California Polytechnic State University	Biezad	Undergraduate	Ethics as Philosophical History for Engineers	Part of a Course*
Lafayette College/ Rutgers University	Rossmann	Undergraduate	Engineering a Catastrophe: Ethics for First-Year STEM	Part of a Course*
Michigan Technological University	Troesch	Undergraduate	Phenomenological Approach to Engineering Ethics Pedagogy	Course
Colorado School of Mines	Smith	Undergraduate	Corporate Social Responsibility Course	Course
University of Wisconsin–Madison	Grossenbacher	Undergraduate	Team Ethics Assignment: Based on Engineering Student Co-Op Experience	Part of a Course*
Stanford University	Hariharan, Shepard, & Shariq	Undergraduate	Global Engineers' Education Course	Course
Massachusetts Institute of Technology 2	Epstein, McGee, & Harvey	Undergraduate	Terrascope – <i>a Freshman Learning Community</i>	Multiple Courses
Colorado School of Mines	Hitt et al.	Undergraduate	Nature and Human Values Course	Course
United States Coast Guard Academy	Jackson et al.	Undergraduate	Ethics Activities in the Civil Engineering Curriculum at the United States Coast Guard Academy	Multiple Courses
Northeastern University	Saulnier, Tillman, & Lenihan	Undergraduate	Multiyear Engineering Ethics Case Study Approach	Multiple Courses
Purdue University	Brightman et al.	Graduate	Prime Ethics: Purdue's Reflective & Interactive Modules for Engineering Ethics	Part of a Course*
Texas State University	Hanks et al.	Undergraduate	NanoTRA: Texas Regional Alliance to Foster Nanotechnology Environment, Health, and Safety	Multiple Courses
Colorado School of Mines	Leydens, Lucena, & Johnson	Undergraduate	Enacting Macroethics: Making Social Justice Visible in Engineering Education	Multiple Courses

University	Author(s)	Graduate, Undergraduate, or Other	Title	Duration of Intervention
Indiana School of Medicine–South Bend and University of Notre Dame	Eggleston et al.	Graduate; Faculty	Ethics when biocomplexity meets human complexity (role-play workshop) and Nanosilver Linings Case	Workshop*
University of Illinois at Urbana-Champaign	Loui	Undergraduate	Ethics Sessions in a Summer Undergraduate Research Program	Part of a Summer Program*

*Note: These instances were considered “Activities” During Analysis in this Study

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Declarations

Conflict of Interest The authors report no conflicts of interest exist associated with the publication of this work.

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