Assessment of FE ethics performance and experiences integrating ethics into the curriculum in a Civil Engineering department at a military institution [Research Paper]

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ABET underscores the importance of ethics in engineering education, requiring programs to cultivate professional and ethical responsibility. Virginia Military Institute (VMI) offers a civil and environmental (CE) engineering curriculum that integrates technical knowledge with leadership training, emphasizing ethical decision-making. As a CE program, VMI follows the ABET requirements for ethics to be assessed and evaluated as a student outcome (SO 4), specifically the ability to recognize ethical responsibilities in engineering situations and make informed judgments. ABET CE program criteria also specifies that the CE curriculum must include the application of the American Society of Civil Engineering (ASCE) code of ethics to ethical dilemmas. VMI's approach aims to embed ethics within both the curriculum and the broader educational experience.

Beyond a traditional CE curriculum, discussions of ethics arise in CE courses, Leadership Education and Development (LEAD) programs, and the Reserve Officers' Training Corps (ROTC) training, allowing students to reflect on the ethical implications of their engineering choices. Furthermore, in an extracurricular capacity, VMI's Honor Court further promotes a culture of integrity and accountability among students. Evidence regarding the extent to which VMI's curriculum meets these standards, including methods to approach, type of application, and correlation to industry experience, are presented in the paper.

Lastly, this paper assesses the performance of VMI's CE students by analyzing longitudinal data from ethics-related questions on the Fundamentals of Engineering (FE) exam. Taking the FE exam is a key graduation requirement for all CE students at VMI, providing a quantitative measure of the effectiveness of the institute's ethics education. This analysis will focus on identifying trends in student performance over time, offering insights into how well VMI prepares its students for ethical challenges in their professional careers. Overall, this paper provides a comprehensive review of the integration of ethics in VMI's CE program, highlighting the synergy between technical education, ethical leadership, and military values.

1. Introduction

Engineers are expected to uphold ethical standards as an essential element of their profession [1,2]. Ethical codes are commonly established by engineering societies, such as the American Society of Civil Engineers (ASCE) [3], the Institute of Electrical and Electronics Engineers (IEEE) [4], the American Society of Mechanical Engineers (ASME) [5], and the National Society of Professional Engineers (NSPE) [6]. These codes of ethics provide lists of generic rules of practice for engineering professionals in how they approach their professional duties, including interactions with others [3-6]. Because ethics is important to the engineering profession, questions on ethics are included in the Fundamentals of Engineering (FE) Exam [7]. Ethics is also recognized by ABET within Criterion 3 on Student Outcomes [8]. These requirements further emphasize the importance of engineering students to receive ethical

guidance while in the university setting, urging university programs to include ethics in engineering education at the undergraduate level.

In the classroom, engineering ethical formation may include discussions of engineering codes of ethics and/or case studies. However, ethical formation has the potential to take place beyond the classroom. Within a unique military framework, Virginia Military Institute (VMI) students are continuously exposed to ethics through leadership courses, military training, and a single-sanction Honor Code. This paper analyzes the various avenues in which engineering students at VMI are exposed to ethics and how each has the potential to contribute to their ethical formation. Performance on FE exam ethics questions is also included as quantifiable evidence of ethical formation over the last decade.

2. Background and Motivation

Professional engineering licensure was established primarily due to questionable ethics when Clarence T. Johnston recognized that the *engineers* and *surveyors* signing documents were not qualified [9]. As a result, Johnston led efforts for Wyoming to begin regulating engineering, and other states followed suit soon after [9]. Ethics have been a critical component of the engineering profession since the beginning. According to Baraket [10], engineering ethics provide a "framework that brings most of the non-technical aspects of the profession…into engineering practice [10]." These aspects can reach beyond legal limits and aspects of personal ethics [10], resulting in challenges and solutions beyond the context of a binary set of rules. Resultantly, engineering ethics education can pose challenges when considering the vast applications of ethics in engineering practice.

Engineering ethics education is recognized by both ABET for accreditation and the National Council of Examiners for Engineering and Surveying (NCEES) for testing and licensure. Student Outcome 4 (SO 4) in ABET Criterion 3 requires that students gain "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 [8]." Because of this criterion, ABET-accredited engineering programs are required to assess student learning related to engineering ethics. NCEES has also encouraged engineering ethics education by including questions on the FE exam pertaining to ethics and the engineering profession [7].

One avenue to introduce engineering ethics in an educational setting is through codes of ethics. Many professional societies (e.g., ASCE, IEEE, ASME, and NSPE) have codes of ethics to guide the professional practice of engineering [3-6]. These codes base decisions on deontological principles – where rules govern action [11]. While deontology can be an acceptable philosophical theory for some decisions and actions, others may require further reflection. Focusing on virtue ethics is another approach that may lead to a more holistic ethical formation for engineers. Because virtue and character are linked, character education could provide a means of developing virtuous engineers [11]. McDonald [11] proposes seven elements to promote character education of engineers:

1. Assign institutional value (by having a university recognize the importance of virtue education)
2. Foster desire (to be a virtuous engineer)
3. Teach about virtue (to understand the language and become aware of it)
4. Mentor (to improve awareness and provide models of virtuous engineers)
5. Practice (through experiential learning or challenges)
6. Enforcement and rehabilitation (to learn from mistakes and improve oneself)
7. Reflection (to critically review oneself and learn from experience)

Character education is prevalent at a military-focused institution where values of honor, respect, and integrity are ingrained in the culture. Therefore, a closer look at how programs at VMI provide character education may provide insight into the ethical formation of engineering students.

A study by Davis and Butkus [12] at the United States Military Academy (USMA) sought to recognize a link between student performance on ethics questions like the FE exam (not actual FE questions) and the moral character development program at USMA. In completing FE-style questions, students were particularly challenged by relationships among employers, clients, and engineers. As a result, they recommended beginning ethics education early in the engineering curriculum through engineering design. While a link between student performance and the USMA program was not quantitatively recognized based on the study, Davis and Butkus [12] established links between seven Army values, the USMA curriculum, and the NSPE code of ethics. The seven Army values included loyalty, duty, respect, selfless service, honor, integrity, and personal courage.

This paper evaluates how the ethical formation of engineers has the potential to take place within the unique military-focused structure of VMI. A military-focused institution has the potential to embed character education, which may promote the formation of virtuous engineers, thereby improving their understanding of engineering ethics. Performance on FE exam ethics questions is used as a quantitative measure of students' understanding of engineering ethics over the past 9 years. This study is similar to the USMA study in that it considers a military-focused institution, identifying the various avenues for the ethical formation of students. However, this study differs from the USMA study in that it evaluates actual FE performance on ethics questions. In contrast, the USMA study considered performance on FE-style questions (not actual FE questions). While it is not a true replica of the USMA study, it is a means to provide more data to identify whether programs at a military-focused institution affect students' understanding of engineering ethics.

3. VMI Engineering Curriculum, ABET SO 4, and Assessment

VMI’s Civil Engineering (CE) program uniquely integrates technical education, ethical leadership training, and military values, creating a comprehensive framework for student development. The CE curriculum addresses ethical responsibilities in engineering through core and elective courses, aligning with ABET's Student Outcome 4 (SO 4), which focuses on recognizing and addressing ethical responsibilities in engineering contexts. Core courses such as CE Fundamentals, Environmental Engineering, Transportation Engineering, CE Seminar, and CE Design Capstone, as well as elective courses like Hazardous Waste Treatment, emphasize

ethical decision-making and provide specialized applications of engineering ethics. Although other courses incorporate discussions of ethics as a part of the course objectives, VMI currently tracks only the aforementioned courses for ABET's continuous improvement process [13].

To ensure the program meets ABET SO 4 requirements, VMI conducts annual assessments and evaluations of these assessments across key CE courses (Table 1). The course objective(s) and assessment method(s) related to ethics for the courses tracked for ABET continuous improvement of SO 4 are summarized in Table 1. Faculty use a variety of approaches, including ethics-focused essay questions, integration of real-world scenarios, and rubrics emphasizing ethical impacts, to evaluate students' understanding of ethical principles. Internal program assessments show faculty incorporate continuous improvement strategies related to ethics, such as adding essay questions on ethical dilemmas, inviting professionals to discuss real-world ethical challenges, and refining assignments to better assess ethical decision-making.

Additionally, CE students who pursue a minor in other majors—such as Computer and Information Science (CIS), Electrical and Computer Engineering (ECE), English, Business and Economics, Math, Physics, and Psychology, to name a few—also gain exposure to ethical considerations. These programs further broaden students' understanding of ethical issues across diverse disciplines, complementing their engineering education and enhancing their ability to navigate complex moral challenges [14].

Beyond technical education, VMI's Leadership Education and Development (LEAD) program enhances students' understanding of ethical leadership through interdisciplinary coursework that integrates theory and practice. Students must take at least one LEAD course – the Core Curriculum Leadership Course. LEAD courses employ case studies to explore ethical approaches to leadership, encouraging students to analyze complex situations involving organizational systems, ethical climates, and cultural influences. VMI's Center for Leadership and Ethics further supports these efforts by offering programs that strengthen critical thinking and ethical decision-making, empowering students to lead with integrity in diverse contexts [15].

Ethical leadership development is reinforced through mandatory participation in the Reserve Officers' Training Corps (ROTC), where students gain hands-on leadership experience within a military framework. All students must participate in one of the five ROTC branches at VMI (Army, Air Force, Navy, Marines, and Space Force), with the majority enrolled in Army ROTC, including those cadets not commissioning after graduation. This consistency ensures a comprehensive foundation in leadership and ethics for every student. Each ROTC branch offers its coverage of ethics in courses like "Leadership and Ethics" and "Leading People and Effective Communication" to sharpen communication and organizational leadership skills, preparing students for the responsibilities of commissioned officers or other professional roles [16]. The activities and implementation of these courses vary by year, with eight sections offered per semester and up to four instructors per section.

Table 1: VMI Course Objectives and Assessment Method(s) for ABET SO 4

Course Title	**Course Objective(s)**	**Assessment Method(s)**
CE Fundamentals (Required, 1st year course)	Students will demonstrate knowledge of professional engineering issues, including ethics, licensure, and VMI's Civil Engineering curriculum. *Multiple guest lecturers' visitations are also included in the course plan with requests to emphasize ethical issues*	Individual essay on why it is important for civil engineers to conduct themselves in an ethical and honorable manner Quizzes Semester Paper
Environmental Engineering (Required, 2nd year course)	Introduce students to drinking water and wastewater treatment theory and teach students how to design basic water and wastewater treatment unit processes.	Individual essay on ethical and professional responsibilities during remediation of an environmental contaminant
Transportation Engineering (Required, 3rd year course)	Summarize the importance of transportation design and modes and recognize the impact such plans have on the economy, environment, and society.	Exam questions
CE Seminar (Required, 4th year course)	Understand engineering ethics and the responsibilities of a professional engineer. Understand the transition from student to professional engineer. *Multiple guest lecturers on ethics are also included in course plan without assessment*	Semester Paper with specific points allocated for proper credit and citations
CE Design Capstone (Required, 4th year course)	Apply principles of civil engineering design from several disciplines to realistic engineering design problems, including safety, applicable design codes, and standards of practice. Learn to effectively communicate design project information in reports, plans, specifications and to examine issues underlying engineering design decisions.	Quizzes
Hazardous Waste Treatment (Elective, 4th year)	For a given contaminant and site, develop a science-based remediation plan which utilizes physicochemical, biological, thermal, and/or stabilization treatment methods. Recommend alternatives to waste-generating processes within the context of sustainability and life cycle assessment.	Test questions Exam questions *Assignments and class discussion on remediation case studies also included but not assessed at this time*

VMI's commitment to ethics and integrity is exemplified by its Honor Code, which declares, "A student will not lie, cheat, steal, nor tolerate those who do." This code upheld through the Honor System, is central to student life and fosters a culture of accountability and ethical conduct. New students undergo rigorous education on the Honor System, led by the Honor Court, instilling values that define the VMI experience [17]. The honor system at VMI is a single-sanction system, reinforcing the importance of personal integrity and ethics in a student's life at VMI.

The program's alignment with ABET standards is further supported by its commitment to correlating ethics education to industry experience. Guest lectures by industry professionals and case studies allow students to examine practical applications of engineering ethics, fostering an understanding of how ethical decisions impact society and the environment. This combination of rigorous academic instruction, leadership training, and industry-relevant practices ensures that VMI graduates are well-prepared to navigate ethical challenges in their professional careers.

4. Quantitative Ethics Evaluation

An additional assessment method implemented at VMI in the CE department is the Fundamentals of Engineering Exam (FE Exam) results. The FE exam in Civil Engineering has been offered in some form since 1965, with the discipline-specific version in place since 1996. In the early 1990s, the concept of using the FE exam as an outcomes assessment tool at the university level came about, and the outcomes reports began to be released to each university. When these reports were generated, the test was offered twice a year (April and October) on paper as an eight-hour multiple-choice exam. In January 2014, after extensive research and planning, it shifted to a computer-based test and was offered year-round at testing centers [9]. When this transition was made, the test shifted to focus on specific disciplines with a six hour time limit. With that history in mind, the data included in this paper focuses on aggregated test scores from the fall academic semester from 2014 onwards using data from the computer-based tests.

The number of students from VMI taking and passing the FE exam each semester and year can be seen in Figure 1. All CE students must take, but not pass, the FE exam as a graduation requirement. Data was sourced from FE outcome reports supplied to the university by NCEES. Unfortunately, when registering and taking the FE exam at the testing center, not all students attribute their attendance to VMI, leaving their scores out of the VMI FE outcomes report. In 2022, FE outcome reports shifted to being requested annually rather than by semester, which is why the last three years in Figure 1 only display annual data. For consistency, only historical data from fall semesters was included as most students take the exam in the fall (average 74%, range 53%-91%). Thus, the number of students taking the exam each year does not always match the university's civil engineering graduation numbers. The pass rates are consistent with historical data [19], except for 2020, when the graduation requirement was waived. In this year, far fewer students took the FE exam due to the COVID-19 pandemic; thus, the pass rate was somewhat inflated. In 2017, 53% of the students took the exam in the fall semester, also inflating the pass rate in the fall semester.

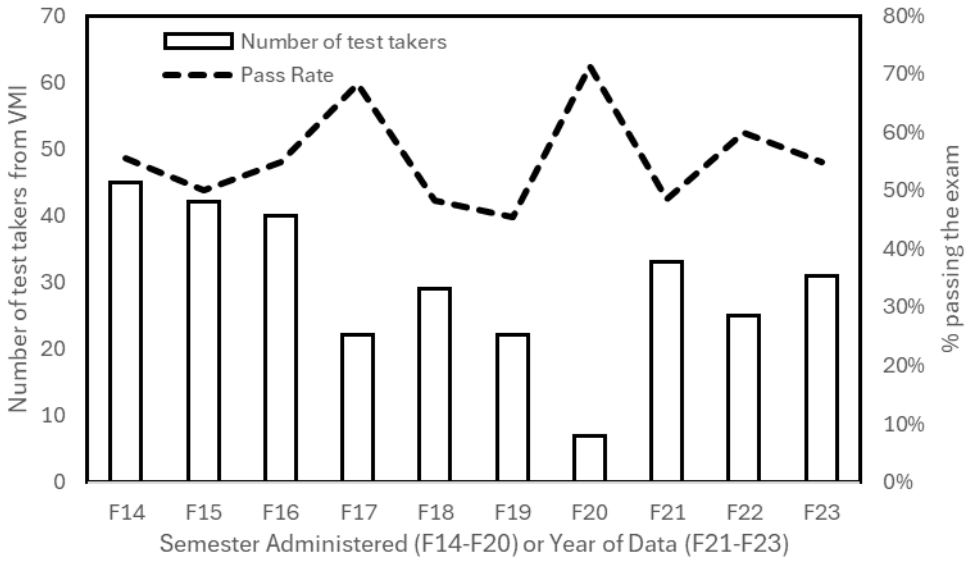

Figure 1: Number of FE exam takers from VMI by year and semester, along with the pass rate (%). Data was aggregated into yearly FE outcome reports starting in early 2022.

Data from the ethics category on the FE outcome report was examined more closely to examine ethics outcomes in the curriculum (Figure 2). The data shown in Figure 2 is presented as a scaled score, which is normalized to FE Civil Exam performance among ABET-accredited programs in the same commission as VMI [20]. As shown in Figure 2, VMI's performance is consistently below that of similar ABET programs, even with the curricular ethics integration described above. Historical data before 2014 was presented in a previous paper [19], with similar trends relative to comparable universities in the "ethics and professionalism category" (previously called "ethics and business"). The ethics and professionalism category consistently contains four questions on the FE exam [20].

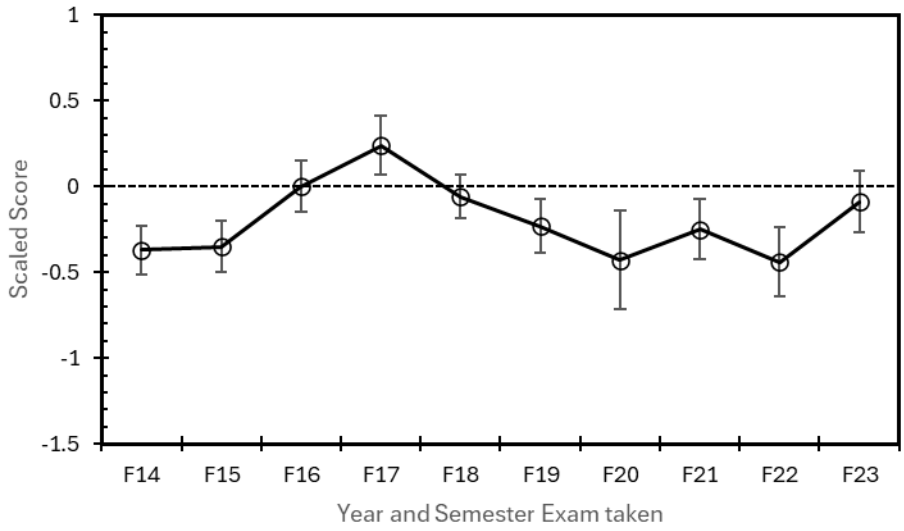

Figure 2: Scaled FE scores for VMI in the Ethics and Professionalism category only. Error bars indicate the standard deviation for VMI as defined by NCEES [20].

5. Discussion

VMI’s Civil and Environmental Engineering program provides a unique framework that integrates technical education, ethical leadership, and military values. Ethics are emphasized throughout the curriculum via core courses, electives, the ROTC program, and VMI's Honor System, ensuring students are exposed to diverse perspectives on ethical decision-making. However, the analysis of FE exam results highlights an opportunity for improvement, as VMI students' performance in the ethics category is consistently below that of comparable ABET programs.

This study found similar results to those observed at the United States Military Academy (USMA) [12], where FE-style questions were used to evaluate ethics knowledge, reinforcing that ethics education within a military-focused institution fosters moral responsibility and character development; however, this particular ethics knowledgebase is not directly related to ethics questions on the FE exam. As recommended by the USMA [12], the Defining Issues Test (DIT) [21] may be more appropriate for evaluating the overall ethical formation of engineering students, whereas the FE exam results evaluate specific professional ethics.

This data reinforces the notion that professional engineering ethics must be intentionally included within the engineering curriculum because alternative programming cannot be relied upon for learning how to apply these specific principles. The FE ethics questions focus on codes of ethics, liability, licensure, and contracts [7]. While it is possible VMI students are prepared to handle moral and ethical dilemmas, the FE questions do not assess that preparation.

This study has several limitations related to data collection and general use of the FE exam. Data is missing when students do not select VMI as their university when taking the FE exam. The opportunity to perform well on ethics is limited, with only four ethics questions on average used to evaluate a student's ethics knowledge on the FE exam. The FE exam is also inherently limiting due to the assessment challenge under a time crunch with multiple-choice-style questions. This trend was noticed by VMI and noted in the recent ABET report to integrate the ASCE code of ethics into two mandatory Civil Engineering senior-year courses during upcoming curriculum adjustments.

6. Conclusion and Recommendations

Because the FE data consistently shows a below-average performance on ethics questions, VMI can consider alternative means to improve students' professional engineering ethical formation and, in turn, FE exam performance. First, VMI can consider tracking how students apply ethical frameworks in capstone projects or internships to observe and evaluate the integration of ethics into engineering practice. Surveys or interviews with alumni can also offer valuable insights into the long-term impact of ethics education on professional practice. Alternative approaches in the classroom may include more case study analysis using codes of ethics, structured reflective essays to focus on professional issues commonly referenced in the FE exam, or simulated ethical dilemmas assessed by faculty and peers. Expanding partnerships with industry professionals to incorporate real-world ethical scenarios into the curriculum would further bridge the gap between theoretical knowledge and practical application.

VMI has many avenues for students' moral and ethical formation; however, professional engineering ethics must continue to be intentionally integrated into the curriculum to prepare engineering students for real-world ethical dilemmas involving professional issues. VMI's Civil Engineering program values ethics and seeks opportunities to meaningfully integrate engineering ethics into a military-focused education. By continually improving teaching methods and assessment strategies, VMI ensures its graduates are not only technically skilled but also ethically grounded professionals capable of addressing the complex challenges of modern engineering practice.

7. References

[1] Australian Council of Professions, "What is a Profession? Australian Council of Professions ACoP," professions.org.au, 2003. https://professions.org.au/what-is-a-professional/ (accessed Jan. 21, 2025).

[2] G. Cheetham and G. E. Chivers, Professions, Competence and Informal Learning. Edward Elgar Publishing, 2005.

[3] American Society of Civil Engineers. 2020. "Code of Ethics." https://www.asce.org/career-growth/ethics/code-of-ethics (accessed Jan. 21, 2025).

[4] Institute of Electrical and Electronics Engineers. "IEEE Code of Ethics." 2020. https://www.ieee.org/about/corporate/governance/p7-8.html (accessed Jan 21, 2025).

[5] The American Society of Mechanical Engineers. "Ethics in Engineering." 2025. https://www.asme.org/about-asme/governance/ethics-in-engineering (accessed Jan. 21, 2025).

[6] National Society of Professional Engineers. "NSPE Code of Ethics for Engineers." 2019. https://www.nspe.org/resources/ethics/code-ethics (accessed Jan. 21, 2025).

[7] National Council of Examiners for Engineering and Surveying. "FE Exam." 2025. https://ncees.org/exams/fe-exam/ (accessed Jan. 21, 2025).

[8] ABET. *Criteria for Accrediting Engineering Programs.* 2024. Baltimore, MD: ABET.

[9] NCEES. *The History of the National Council of Examiners for Engineering and Surveying*. 2020. Greenville, SC, USA. National Council of Examiners for Engineering and Surveying. https://ncees.org/wp-content/uploads/2022/09/2020_history_web_version.pdf (accessed Jan. 21, 2025).

[10] N. Barakat, "Engineering ethics: A critical dimension of the profession," *2011 IEEE Global Engineering Education Conference (EDUCON)*, Amman, Jordan, 2011, pp. 159-164, doi: 10.1109/EDUCON.2011.5773130.

[11] K. McDonald. "Virtue in Engineering Ethics Education." 2022. Proceedings of the *ASEE 2022 Annual Conference*. Minneapolis, MN. 26-29 June.

[12] G. Davis and M. Butkus. 2008. "A Study in Engineering and Military Ethics." Proceedings of the 2008 Annual American Society for Engineering Education Conference and Exposition. Pittsburgh, PA. 22-25 June.

[13] "Program: Civil Engineering, B.S. – Virginia Military Institute - Modern Campus Catalog" *www.VMI.edu*., 2025. https://catalog.VMI.edu/preview_program.php?catoid=36&poid=2636&returnto=1395 (accessed Jan. 22, 2025).

[14] "Virginia Military Institute - Modern Campus Catalog" *www.VMI.edu*., 2025. https://catalog.VMI.edu/index.php/css/public_custom.php (accessed Jan. 22, 2025).
[15] "VMI Center for Leadership and Ethics (CLE)," *www.VMI.edu*., 2024. https://www.VMI.edu/cadet-life/cadet-leadership-and-development/cle/ (accessed Jan. 22, 2025).
[16] "ROTC at VMI," *www.VMI.edu*., 2024. https://www.VMI.edu/cadet-life/cadet-leadership-and-development/rotc/ (accessed Jan. 22, 2025).
[17] "Honor System - Cadet Life – Virginia Military Institute," *www.VMI.edu*. https://www.VMI.edu/cadet-life/cadet-leadership-and-development/honor-system/ (accessed Jan. 22, 2025).
[18] "VMI Mission" www.VMI.edu
[19] C. Newhouse and D. Johnstone, "Improving FE Pass Rates through Changes in Attitude," Proceedings of the ASEE Southeast Section Conference, 2012.
[20] NCEES. *Using the Fundamentals of Engineering (FE) Examination as an Outcomes Assessment Tool*. 2024. Greenville, SC, USA. National Council of Examiners for Engineering and Surveying https://ncees.org/wp-content/uploads/2024/09/FEOAT-white-paper-2024.pdf
[21] Online Ethics Center for Engineering and Science. *Defining Issues Test (DIT and DIT-2)*. 2025. https://onlineethics.org/cases/evaluation-tools/defining-issues-test-dit-and-dit-2 (accessed Feb. 20, 2025).