DOI https://doi.org/10.32782/2307-9770.2025.13.02.02
UDC 378.147.091.3:001.8:[62:17]

The Indispensable Imperative: Navigating the Evolving Landscape of Teaching Engineering Ethics in a Dynamic Societal Context

Priliepo, N.*, Borovyk, O.

Poltava State Agrarian University, Poltava, Ukraine

Received: *09.06.2025* ***Accepted***: *24.06.2025*

Abstract. In an era of rapid technological advancement and escalating societal expectations, the effective teaching of engineering ethics has become an indispensable imperative. While traditional pedagogy successfully imparts foundational ethical principles and codes of conduct, a significant body of literature suggests a critical chasm between this theoretical knowledge and the complex, high-pressure realities of professional practice. This study addresses this existing gap between the abstract ethical principles taught in engineering curricula and real-life practice, aiming to empirically investigate the shortcomings of current pedagogical approaches and propose evidence-based recommendations to enhance graduate preparedness. The methodology involved a targeted study with a test group of students, who were assessed through scenarios designed to simulate real-world professional challenges, including conflicts of interest, organizational pressures to cut corners, and psychological factors like obedience to authority. The results revealed a significant discrepancy: while students demonstrated competent theoretical knowledge of ethical codes, they proved largely ill-equipped to apply these principles under simulated organizational pressure, empirically confirming the hypothesized gap. The originality of this research lies in providing empirical validation of the inadequacies in traditional ethics education, moving beyond widespread theoretical critique. It challenges pedagogical models focused solely on abstract principles by demonstrating the decisive impact of organizational and psychological factors on decision-making and refutes the assumption that knowledge of codes is sufficient for ethical practice. Consequently, the findings have profound practical significance, providing a clear mandate for pedagogical change. They form the basis for an actionable framework for educators, advocating for the integration of experiential learning, such as high-fidelity case studies and role-playing, to cultivate practical wisdom and moral courage, thereby offering a blueprint for curriculum enhancement and a foundation for future longitudinal research.
Key words: ethics, education, methodology, societal context, decision-making, organizational pressure.

Необхідний імператив: пошук шляху у швидкоплинному ландшафті викладання інженерної етики в динамічному суспільному контексті

Прілєпо Н. В., Боровик О. Ю.

Полтавський державний аграрний університет, Полтава, Україна

Анотація. В епоху стрімкого технологічного розвитку та зростаючих суспільних очікувань ефективне викладання інженерної етики стало нагальною необхідністю. Хоча традиційні педагогікчні підходи успішно навчають базовим етичним принципам та кодексам поведінки, значний масив існуючих досліджень вказує на існування критичної різниці між цими теоретичними знаннями та складними реаліями професії. Це дослідження розглядає цей існуючий розрив між абстрактними етичними принципами, що викладаються в освітніх компонентах освітніх програм інженерного спрямування, та реальною практикою, з метою емпіричного дослідження недоліків сучасних педагогічних підходів та надання науково обґрунтованих рекомендацій для підвищення готовності випускників-інженерів. Використана методологія включала цільове дослідження проведене з тестовою групою студентів, яких оцінювали за допомогою практичних ситуацій, розроблених для імітації реальних професійних викликів, включаючи конфлікти інтересів, організаційний тиск з боку керівництва та психологічні фактори. Результати дослідження виявили значну проблему – хоча здобувачі вищої освіти продемонстрували достатні теоретичні знання етичних кодексів та розуміння їх принципів, вони виявилися переважно непідготовленими до їх застосування в умовах імітованого організаційного тиску, що емпірично

*

Corresponding Author: Priliepo Nataliia Volodymyrivna. E-mail: nataliia.pryliepo@pdau.edu.ua
Poltava State Agrarian University,
vul. Skovorody, 1/3, Poltava, Poltava region, Ukraine, 36003.
Відповідальний автор: Прілєпо Наталія Володимирівна. E-mail: nataliia.pryliepo@pdau.edu.ua
Полтавський державний аграрний університет,
вул. Сковороди, 1/3, м. Полтава, Полтавська обл., Україна, 36003.

підтвердило гіпотетичну невідповідність існуючого навчання інженерної етики. Оригінальність цього дослідження полягає в наданні емпіричного підтвердження недоліків традиційної етичної освіти, виходячи за межі поширеної теоретичної критики. Воно ставить під сумнів педагогічні моделі, які зосереджені виключно на абстрактних принципах, демонструючи вирішальний вплив організаційних і психологічних факторів на прийняття рішень, і спростовує припущення, що теоретичне знання етичних кодексів інженерів є достатнім для їх впровадження у життя. Виходячи із вищезазначеного, отримані результати мають глибоке практичне значення, надаючи чіткий імператив для педагогічних змін. Вони можуть бути покладені в основу дієвої програми для освітян, що буде підтримувати інтеграцію емпіричного навчання, зокрема, розгляду реалістичних кейсів, рольових ігор та симуляцій для розвитку практичних навичок, пропонуючи таким чином план для вдосконалення освітніх програм та основу для подальших досліджень.
Ключові слова: етика, освіта, методологія, соціальний контекст, прийняття рішень, організаційний тиск.

I Introduction

The significance of engineering ethics cannot be overstated. It serves as the moral compass for a profession entrusted with shaping the physical and digital worlds, directly impacting public safety, environmental health, and overall quality of life. The most fundamental tenet, enshrined in virtually every engineering code of ethics, such as that of the National Society of Professional Engineers (NSPE), is the engineer's duty to «hold paramount the safety, health, and welfare of the public» [1]. This is not an abstract ideal but a tangible commitment with life-and-death consequences. Unfortunately, the history of engineering is punctuated by failures where ethical lapses contributed to tragedy. The Hyatt Regency walkway collapse in Kansas City in 1981, where a design change was made without proper engineering review, leading to 114 deaths, serves as a stark reminder [2]. Similarly, the Challenger space shuttle disaster, meticulously analyzed by Diane Vaughan, revealed how organizational pressures and a «normalization of deviance» could override engineering concerns about safety [3]. These two infamous disasters are not merely technical failures but profound ethical ones, demonstrating the critical need for engineers to possess not only technical competence but moral courage and a steadfast commitment to public well-being. As emphasized in a widely used textbook, «Engineering Ethics: Concepts and Cases», ethical decision-making is integral to responsible engineering practice [4].

Engineering is a profession, distinguished from a mere occupation by its specialized knowledge, commitment to public service, and the trust society places in its practitioners. This trust is fragile and hard-won, as ethical conduct is the bedrock upon which this trust is built and maintained. When engineers act ethically, transparently, and responsibly, they reinforce the public's confidence in the profession. Conversely, scandals like the Volkswagen emissions deception, where engineers were implicated in deliberately designing «defeat devices» to cheat on emissions tests, severely damage this trust, not just in the company involved but in the profession as a whole [5]. As Michael Davis argues in «Thinking Like an Engineer: Studies in the Ethics of a Profession» (1998), professional ethics is about adhering to a standard of conduct that goes beyond mere legal compliance; it's about what defines a «good engineer» in a moral sense. Ethics education, therefore, plays a crucial role in instilling this sense of professional identity and collective responsibility.

Engineering is inherently innovative, constantly pushing the boundaries of what is possible. However, innovation without ethical guidance can lead to unintended and harmful consequences. As new technologies like artificial intelligence (AI), genetic engineering, autonomous systems, and big data analytics emerge, they bring with them a host of novel ethical dilemmas. Sara Baase's «A Gift of Fire: Social, Legal, and Ethical Issues for Computing and the Internet» has long been a key text highlighting the societal impact of computing technologies and the ethical questions they raise [6]. Engineers are at the forefront of developing these technologies and thus bear a significant responsibility to consider their broader societal implications, including bias in AI algorithms [7], privacy in an era of ubiquitous data collection, accountability for autonomous decision-making, and the potential for misuse. Engineering ethics provides the frameworks and cultivates the foresight needed to steer innovation in beneficial and just directions.

The impact of engineering projects on the natural environment is profound and often long-lasting, too. Engineering activities have significant environmental footprints, from resource extraction and energy production to manufacturing and infrastructure development. A growing ethical imperative within the profession is the commitment to sustainability and environmental stewardship. This involves designing products and processes that minimize environmental harm, conserve resources, reduce waste, and address the challenges of climate change. Caroline Whitbeck, in «Ethics in Engineering Practice and Research», emphasizes a problem-solving approach to ethics, which readily applies to designing for sustainability [8]. The concept of «life-cycle assessment» and designing for the «circular economy» are technical approaches with deep ethical underpinnings, reflecting a responsibility to future generations and the planet's health.

Engineering ethics also guides professional conduct, including honesty, integrity, competence, and avoiding conflicts of interest. Engineers must be truthful in their professional reports, statements, or testimony and undertake assignments only when qualified by education or experience. They also have a responsibility to continue their professional development throughout their careers. Ethical codes provide a framework for navigating situations where personal interests might conflict with professional duties, ensuring that decisions are made in the best interest of clients, employers, and the public.

But, the education of future engineers in ethics is increasingly recognizing a crucial gap: the chasm between abstract ethical principles taught in academia and the complex, often «messy», realities of professional practice within organizations. This heightened focus on organizational dynamics, power structures, and the psychological pressures isn't accidental; it's driven by several converging factors that underscore its critical importance.

While proficient in imparting abstract ethical principles and codes of conduct, traditional engineering ethics education often fails to adequately prepare graduates for the complex realities of ethics decision-making within contemporary organizational and societal contexts. This theory-practice gap is increasingly problematic as engineers face escalating pressures from rapid technological advancements, globalization, intense market competition, complex power dynamics within organizations, and heightened public scrutiny regarding the societal and environmental impact. Consequently, engineers may find themselves ill-equipped to navigate real-world ethical dilemmas where professional responsibilities conflict with organizational pressures, personal values, or ambiguous situational factors, potentially leading to unethical conduct, harm to the public, environmental damage, or erosion of trust in the engineering profession.

This study is needed to investigate the specific shortcomings of current pedagogical approaches and identify effective strategies for bridging this gap. High-profile ethical failures in engineering highlight the severe consequences that occur when ethical considerations are inadequately addressed in practice. The existing chasm between academic ethical training and the realities of professional life suggests that current educational models may not adequately emphasize the organizational, psychological, and systemic factors that influence ethical behavior. Therefore, further research is needed to understand how engineering ethics education can be reformed to more effectively integrate these complexities, ensuring future engineers are not only aware of ethical principles but also possess the practical wisdom, courage, and skills to apply them under pressure within diverse and challenging organizational environments.

The purpose of this study is to investigate the existing shortcomings of current engineering ethics education based on the example of the Engineering and Technology Faculty students' test group. The ultimate aim is to propose evidence-based recommendations to enhance the preparedness of engineering graduates to navigate ethical dilemmas effectively and responsibly within dynamic organizational and societal contexts.

To achieve the study's purpose, the following research objectives will be pursued: to critically analyze current pedagogical approaches, content, and assessment methods in engineering ethics education to identify specific limitations in addressing problematic topics; to identify and characterize the common types of organizational pressures (e.g., conflicts of interest, pressures to cut corners, loyalty dilemmas) and psychological factors (e.g., obedience to authority, groupthink, moral disengagement) that engineers frequently encounter in professional practice and analyze students' preparedness to face them; to propose a framework or set of actionable recommendations for enhancing engineering ethics curricula and pedagogical practices to better equip future engineers for navigating the evolving landscape of ethical challenges in their professional lives.

II Materials and Methods

Engineering ethics education, while crucial, often struggles to bridge the significant gap between abstract ethical principles taught in academia and the nuanced realities of professional practice. While case studies are staples, they are often presented retrospectively with clear «heroes» and «villains» or focus on catastrophic failures. This can neglect the mundane ethical dilemmas and incremental decisions made under pressure. As Newberry discusses, there's a persistent challenge in making ethics education truly impactful and relevant to the dilemmas students will face, moving beyond simplistic applications of codes to complex situations [9].

Traditional formats often fail to simulate the pressure of real-world decision-making. Students don't experience the social dynamics or personal career risks involved in raising ethical concerns. While reviews [10] highlight various interventions, the extent to which these fully replicate organizational pressures remains challenging. Knowing the «right» thing is different from having the skills and courage to act on it effectively within an organization. Pedagogy often underemphasizes how to navigate organizational politics or communicate concerns persuasively.

Teaching engineering ethics often focuses on grand ethical theories and codes, which can seem detached from day-to-day organizational drivers like profit motives and resource constraints. There's insufficient content on organizational behavior, corporate culture, and cognitive biases. Much content frames ethical dilemmas as problems solvable by moral individuals, neglecting systemic pressures. Some researchers argue for broadening ethics teaching beyond this individualistic approach to include social ethics and the role of engineers in societal and organizational contexts, thereby addressing the systemic nature of many ethical problems [11]. At the same time, the «micro-ethics» of daily professional conduct might be underrepresented. Teaching content may not adequately help students develop a robust professional ethical identity that can withstand organizational pressures.

As for limitations, assessments often prioritize recall of codes or theories, struggling to assess ambiguous ethical reasoning or likely behavioral responses. So, the challenge lies in moving assessments beyond theoretical understanding to evaluating practical ethical competence. Of course, qualities like integrity and courage are hard to measure through traditional academic assessments, which can only add to the vagueness of the problem.

For our study, we selected 1st and 4th-year students majoring in Industrial Engineering at the Faculty of Engineering and Technology of Poltava State Agrarian University. Considering objective factors, a large and multifaceted study requires many participants and a long time. Beginning with a smaller study group of 5-10 members offers distinct advantages before potentially expanding. In this setting, members often feel more comfortable sharing ideas and asking questions without the pressure of a larger audience. Students perceive group work as beneficial for gaining new perspectives and mutual support, experiences often amplified in smaller, more manageable units [12]. This allowed more focused discussions and efficient problem-solving, ensuring everyone grasps core concepts. It's also easier to effectively communicate and share study habits within a smaller unit. Based on this, in general, 20 students were selected for participation. Each of the two groups (10 students of the 1st course and 10 students of the 4th course) holds members of the same gender, approximate age, and level of education.

At Poltava State Agrarian University, engineering ethics is introduced to students as an integral component of the mandatory first-semester, first-year discipline titled «University Education». This foundational course outlines the key characteristics of higher technical education in Ukraine, incorporating topics pertinent to real-world engineering scenarios, and is generally designed to focus on the student's adaptation to the evolving demands of higher education [13]. For the present study, first-year students were selected because they had recently covered these relevant ethical topics within the preceding 10 months of their university experience. Fourth-year students were chosen as a comparative group; they had also completed this discipline in their first year but had since augmented their theoretical knowledge with practical experience gained through several industrial practicums at different enterprises and factories. Engagement in these industrial, rather than purely academic, practicums is significant, it provides students with tangible experience in navigating multi-generational teams, direct involvement in production processes, and an understanding of organizational management hierarchies.

To effectively investigate the perceived and experienced gap between engineering ethics taught academically and the complex realities of professional practice, a multi-method approach involving interviews, questionnaires, and anonymous surveys was implemented. This allowed for in-depth qualitative insights and broader quantitative comparisons between the target groups: 1st-year students with recent theoretical ethics education, and 4th-year students who supplement this with industrial practicum experience. Before any data collection, formal approval from students was obtained. All participants were provided with a clear explanation of the study's purpose, what their participation would entail, how their data would be used and protected, their right to voluntary participation, and their ability to withdraw at any time without penalty. It was ensured that all instructions were unambiguous and easy to understand.

For the 1st year students, interviews and anonymous surveys explored understanding of ethical principles, how they anticipate applying these in professional settings, and what ethical challenges they foresee. For the 4th year students, interviews and anonymous surveys delved into how their industrial practicums have shaped their views on academic ethics, elicited specific examples of ethical dilemmas observed or experienced, and understood how they navigated workplace dynamics concerning ethical conduct. The content of these surveys and topics of interviews was somewhat based on the standardized DIT and DIT-2 tests – copyrighted psychometric instruments developed by James Rest and colleagues, now managed and distributed by the Center for the Study of Ethical Development at the University of Alabama [14]. While, of course, not the same, created engineering-specific ethical dilemmas were specifically designed to assess students' general understanding and precise application.

Interviews were conducted in April and May 2025 using open-ended questions, allowing flexibility for follow-up. The basic questions for both groups were the same – the only difference was that they asked students to give an answer based on their experiences. All interviews were held in quiet, private locations. These are some examples of asked questions: «When public safety conflicts with project cost or deadlines, how should an engineer prioritize and justify their decision?», «When an engineer's duties to their client, employer, and the public conflict, how should they determine which takes precedence?», «What key ethical issues should engineering teams proactively address at the start of any new project?», etc. Questionnaires and anonymous surveys, conducted at the same time, were used to gather specific information, enabling quantitative comparisons between 1st and 4th-year students, and to collect honest responses on potentially sensitive topics through anonymity. Surveys measured agreement and commonness of the answers with closed-ended questions, trying to gauge true feelings about pressures to act unethically, willingness to report concerns, and actual (unattributed) experiences of ethical breaches during practicums from recipients. Closed-ended questions sounded like «In a situation where an employer's demands conflict with the public's best interest, is an engineer's primary obligation always to the public?» or «Do you believe that university ethics education has adequately prepared you to identify and navigate potential conflicts of interest in professional settings?», etc. The survey was distributed through an online platform (Google Forms). Because these surveys were anonymous, no identifying information (names, specific student IDs) was collected.

Questionnaires were constructed as ethical dilemmas. The core of the dilemmas remains the same for both 1st and 4th-year students, as ethics principles are constant. The key difference lay in the depth of understanding of the contextual factors, the range of potential solutions considered, and the perceived weight of consequences based on experience. These artificially constructed dilemmas were used to reveal how experience shapes professional judgment. Each of the five dilemmas had a specific scenario covering one of the core themes selected for this study. For example, the «Inspired Design Dilemma» had the following scenario: «As a junior design engineer, you're pressed to complete a new product design. You remember a very similar, effective solution to a key problem in a publicly available technical paper from a competitor (not patented). Directly incorporating significant elements would save weeks and likely improve the product. Your company rewards rapid innovation». In this example, the main ethical dilemma is about the ethicality of «borrowing» from the competitor's public design to meet deadlines and impress your bosses. These dilemmas were discussed directly within the groups, comparing their reasoning, the factors they prioritize, and the proposed solutions, highlighting how experience (or lack thereof) shapes ethical decision-making in practice.

Despite their capacity to reveal nuanced differences, these dilemmas are intentionally designed around simple principles, such as honesty, public safety, responsibility, professional integrity, etc. The scenarios are typically straightforward, presenting clear-cut conflicts that students can readily grasp, even with limited real-world engineering experience. This inherent simplicity ensures that the fundamental ethical tension is easily understood, allowing students to engage with the core problem without being bogged down by excessive technical complexity or obscure contextual details. The goal is to provide an accessible entry point for ethical reasoning, laying a foundation before possibly exploring more intricate variations.

The comprehensive analysis of student responses employed a robust mixed-methods research design, integrating quantitative and qualitative data processing techniques to capture the full spectrum of insights. For data derived from anonymous Google Forms surveys featuring closed-ended questions, statistical analysis was conducted primarily using software packages such as advanced functionalities within Microsoft Excel. The initial phase involved generating frequencies and percentages for categorical responses to understand the distribution of choices and opinions. Then, they were visualized using bar charts, histograms, or pie charts to provide an accessible overview. For rich textual data gathered from written open-ended questions within surveys and detailed transcripts of group discussions and individual interviews focused on ethical dilemmas, qualitative analytical methods were crucial. Qualitative content analysis focused on interpreting the meaning and significance of content within its context, examining the presence, meanings, and relationships of specific words and concepts. Narrative analysis was used for content that involved storytelling or detailed accounts of reasoning processes to understand how students construct meaning and structure their ethical arguments.

The findings from quantitative and qualitative analyses were integrated to provide a more holistic and validated understanding. For instance, detailed explanations found in open-ended answers or discussion transcripts were illuminated and contextualized by the statistical trends identified in survey responses. Conversely, themes emerging from qualitative data provided new hypotheses to be tested quantitatively in future studies.

III Results

Given the critical importance of ethics in engineering, its education cannot be a static enterprise. It must be dynamic and responsive to the evolving nature of the profession itself and the ethical challenges it faces. Early approaches to engineering ethics education often focused heavily on the memorization and application of professional codes of ethics. While understanding codes is essential, contemporary ethics education recognizes that codes alone are insufficient for navigating complex, novel, or ambiguous ethical dilemmas. As Michael Davis argued, codes are a good starting point, but true ethical competence requires developing skills in ethical reasoning, critical thinking, and moral imagination [15]. Modern pedagogy, therefore, emphasizes the development of these cognitive skills, enabling students to analyze situations, identify ethical issues, consider different perspectives, and justify their decisions based on sound ethical principles. The field has seen significant pedagogical innovation aimed at making ethics education more engaging and effective for engineering students, who are often pragmatic and problem-oriented.

Case studies remain a cornerstone, but they have evolved from simple, often decontextualized scenarios to more complex, realistic, and open-ended narratives that reflect real-world engineering, such as those discussed by M. S. Pritchard [4]. These typically include organizational pressures and stakeholder conflicts.

Different *active learning strategies* are becoming more popular. Role-playing scenarios allow students to experience ethical dilemmas from different perspectives and practice communication skills. Debates on controversial ethics issues can sharpen critical thinking and argumentation, and simulations can immerse students in decision-making processes under pressure [16].

A particularly influential, relatively recent development is the *GVV (Giving Voice to Values)* curriculum pioneered by Mary Gentile [17]. GVV shifts the focus from ethical analysis (identifying what is right) to ethical implementation (developing strategies to act on one's values effectively, especially in the face of opposition or organizational pressures). This approach resonates strongly with the practical orientation of engineering students and addresses the challenge of moving from knowing to doing.

As noted earlier, new technologies bring new ethical challenges. Engineering ethics education must continuously update its content to address these. This includes AI, biotechnology, and cybersecurity ethics. It's also increasingly recognized that individual ethical decision-making is heavily influenced by organizational culture, power dynamics, financial pressures, and systemic factors of one's place of employment. As such, ethics education is expanding to include concepts like groupthink, normalization of deviance, obedience to authority, ethical leadership, organizational climate, and moral distress. So, assessing the effectiveness of ethics education is a complex but crucial endeavor. This field is moving beyond simply testing knowledge of codes or theories, now, efforts are focused on assessing changes in students' moral reasoning capabilities, often using instruments like the Defining Issues Test (DIT), or developing specific rubrics to evaluate their ethical analyses in written assignments or case study responses.

In many foreign countries, accreditation bodies, most notably ABET (Accreditation Board for Engineering and Technology) in the United States, play a significant role in shaping engineering curricula, including ethics education. ABET's Criterion 3, student outcomes, explicitly requires programs to demonstrate that their graduates have «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» [18]. This mandate ensures that ethics remains a core component of engineering education and drives institutions to evaluate and improve their approaches continuously.

In real life, engineers frequently navigate a complex landscape where organizational pressures and internal psychological factors can significantly challenge their ethical decision-making and professional integrity. Typically, they include *conflicts of interest* that arise when an engineer's interests (financial, familial, reputational, etc.) or loyalties could improperly influence, or appear to influence, their professional judgment or actions, potentially compromising objectivity or fairness in their duties. For example, recommending a supplier in which they have a personal financial stake.

Pressures to cut corners driven by tight deadlines, budgetary constraints, or competitive demands may compromise quality, safety standards, thoroughness of testing, or ethical considerations to save time or money. This can involve using substandard materials or skipping crucial design verification steps. Engineers often feel strong loyalty to their employer, colleagues, or clients. This can create *loyalty dilemmas* and conflicts when these loyalties clash with their primary responsibility to public safety, health, and welfare, or with legal and ethical codes. For instance, being asked by a manager to conceal a design flaw from a client.

While not inherently unethical, relentless focus on meeting aggressive timelines and staying under budget (*schedule and budgetary constraints*) can create an environment where ethical considerations are downplayed or ignored, leading to decisions that prioritize project completion over safety or quality. *Pressure to conceal informatio*n or *misrepresent data* can involve being asked to withhold negative test results, exaggerate a product's capabilities, or downplay potential risks to secure a contract, appease stakeholders, or avoid regulatory scrutiny.

Simultaneously, engineers are susceptible to several psychological factors that can impair ethical judgment, for example, *obedience to authority* – a well-documented phenomenon [19] where individuals are inclined to comply with directives from perceived authority figures, even if those directives conflict with their own ethical judgment or professional standards. An engineer might follow a superior's unethical instruction due to fear of reprisal or deference to their position. *Groupthink* occurs in cohesive groups where the desire for conformity and unanimity overrides realistic appraisal of alternative courses of action or critical evaluation of ethical implications. Individuals may suppress dissenting opinions to maintain group harmony, leading to poor and potentially unethical collective decisions.

A set of psychological mechanisms that individuals use to rationalize or justify unethical behavior, allowing them to act against their moral standards without self-condemnation, is known as *moral disengagement*. Examples include euphemistic labeling (calling bribery «facilitation fees»), advantageous comparison (comparing an unethical act to something worse), or displacing responsibility. In large teams or complex organizational structures, individuals may feel less personal accountability for the outcomes of collective actions, believing that others are responsible or that their contribution is insignificant. This *diffusion of responsibility* can lead to inaction in the face of ethical concerns.

Normalization of deviance is a gradual process where small, seemingly minor deviations from accepted standards or ethical norms become accepted practice over time. Each small step away from the ideal seems inconsequential, but cumulatively, they can lead to significant ethical lapses or even disasters, as the «abnormal» becomes the «new normal». Understanding these intertwined organizational and psychological dynamics is crucial to identifying and mitigating ethical risks, thereby upholding their commitment to public safety and professional standards. As for the results of the conducted research, the primary difficulty in numerically representing data from interviews and open-ended questions is the unavoidable loss of rich nuance and context. The researcher must interpret and code subjective, often conditional, responses into fixed categories, a process that inherently oversimplifies complex personal beliefs and introduces potential bias. Therefore, as this study is a cross-sectional analysis of existing opinions rather than a psychological survey, the charts successfully fulfill their intended purpose by providing a clear and impactful snapshot of the prevailing attitudes within each cohort at a specific moment in time.

The interview data (Fig. 1) reveal a systematic erosion of students' stated commitment to foundational ethical principles as they progress through their engineering education. While first-year students express near-unanimous agreement with core ethical tenets, fourth-year students consistently show a diminished, more cynical perspective. This suggests that exposure to the perceived realities of the profession tempers their initial idealism and forces a recalculation of what is practically achievable versus what is ethically ideal.

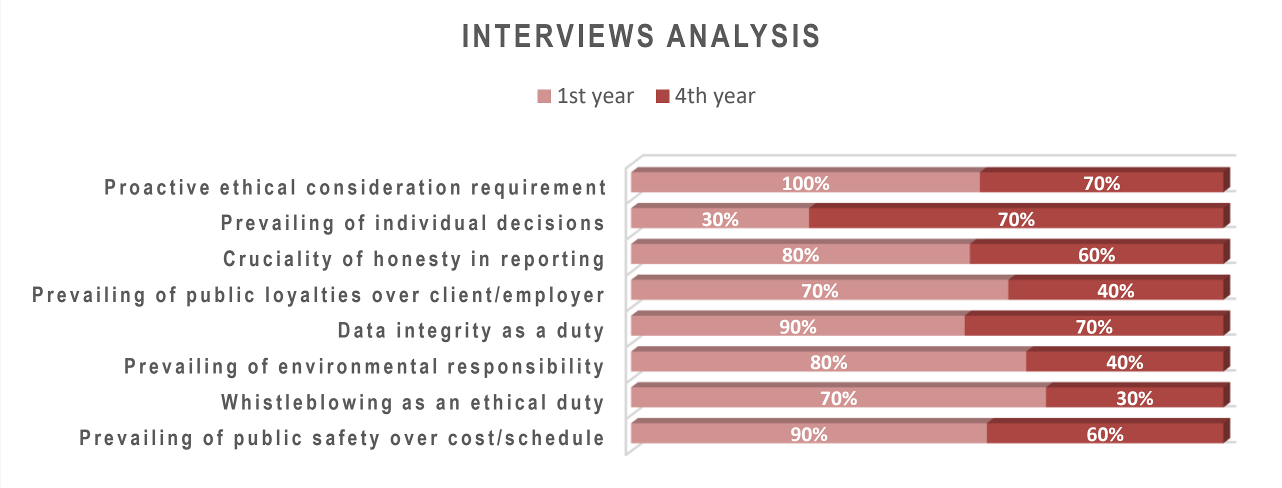

Fig. 1. Graphical representation of interview analysis

There is a stark decline in the prioritization of public good over other pressures. The belief that public safety should prevail over cost/schedule drops from 90% to 60%, and that public loyalty trumps loyalty to a client/employer fall from 70% to 40%. Similarly, commitment to environmental responsibility plummets from 80% to 40%. This indicates that senior students are internalizing the organizational and financial pressures that often conflict with their duty to the public. The most dramatic shift is seen in the perception of «whistleblowing as an ethical duty», which falls from 70% among first-year students to a minority position of 30% among fourth-year students. This aligns perfectly with previous data showing a perceived lack of support and a fear of reprisal. Senior students have clearly learned that speaking out, while ethically correct in theory, is a personally risky and often unsupported action in practice.

The only metric that increases is the «prevalence of individual decisions», which more than doubles from 30% to 70%. This is a crucial finding. It suggests that as students lose faith in organizational support systems and collective ethical standards, they conclude that ethical choices are ultimately a matter of individual, isolated struggle. They no longer see ethics as a shared, systemic responsibility but as a burden the individual must bear alone. In conclusion, the interview analysis shows that while students may enter their studies with strong ethical convictions, their educational journey – coupled with exposure to professional norms – systematically dismantles this certainty. By their final year, they are less likely to prioritize the public, far less willing to act as whistleblowers, and feel that the burden of ethical decision-making rests solely on their shoulders, highlighting a profound need for an educational model that builds resilience and provides practical strategies for upholding ethics within complex systems.

The data below (Fig. 2) also paints a vivid picture of a «reality check» that occurs as engineering students progress through their academic careers. The findings strongly suggest that as students gain more knowledge and exposure to the profession (through internships, advanced projects, and industrial practicums), their initial optimism is replaced by a soberer and critical understanding of the ethical challenges they will face. Fourth-year students are significantly more aware of the constant pressure in the field and the difficulty of real-life application of ethical principles. Their education has made them more attuned to the gap between classroom ideals and professional realities. The most telling finding is the dramatic drop in perceived «sufficiency of basic education in ethics» from 80% to 30%. First-year students enter with faith in the curriculum, but by their final year, they feel it has not adequately prepared them for the complexities of the real world. The shift from 40% to 0% on «effective engineer support and protection» is alarming. It indicates that senior students have become completely disillusioned, believing that formal systems to protect engineers who act ethically are non-existent or ineffective.

As awareness of external pressures and lack of support grows, students' confidence in their own «effectiveness of pressure resistance» is halved. They realize that navigating ethical dilemmas will be much harder than they initially thought. In conclusion, this data validates the hypothesis that traditional engineering ethics education is insufficient. It shows that as students approach graduation, they increasingly recognize the intense pressures, lack of institutional support, and practical difficulties of applying ethics, leaving them feeling vulnerable and ill-equipped for the professional world.

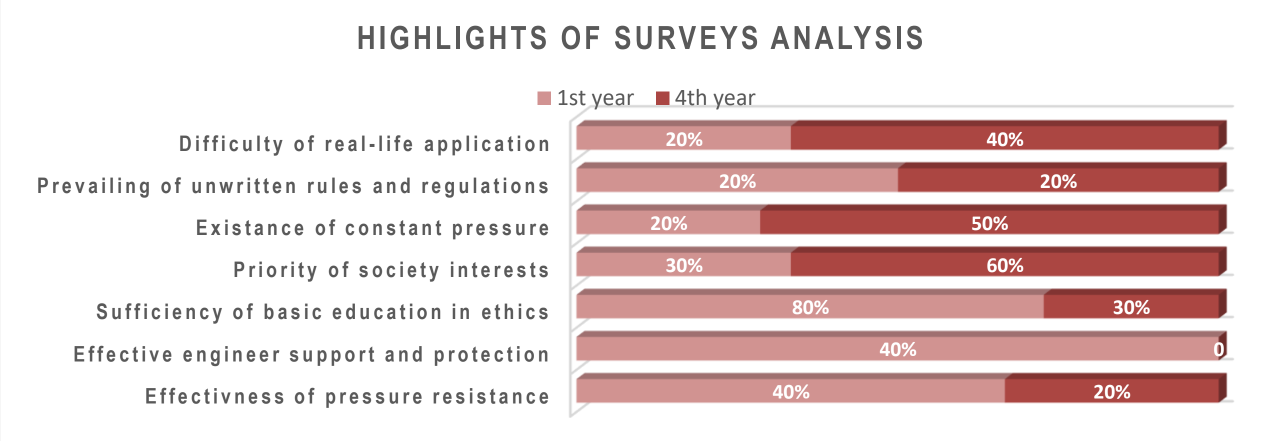

Fig. 2. Graphical representation of surveys highlights

This analysis (Fig. 3) continues to reveal a troubling erosion of ethical absolutism as students advance through their engineering education. The data indicates a consistent shift from idealistic, principle-based decision-making among first-year students to a more pragmatic, and often ethically flexible, mindset among fourth-year students. The most dramatic finding is in the «Substandard Component Dilemma». While 100% of first-year students would insist on the higher moral ground even if it caused delays, this conviction drops to 60% among fourth-year students. This signifies a major shift, where nearly half of senior students are willing to compromise on safety or quality to meet project timelines, a clear nod to perceived industry pressures. There is also a further significant increase in the willingness of senior students to make actively unethical choices. For instance, the readiness to misrepresent data to avoid conflict («Altered Emissions Data») more than doubles from 20% to 50%, and the willingness to deploy a known «Biased AI Algorithm» skyrockets from 20% to 70%. This suggests that senior students see such compromises as a more realistic or necessary part of the job.

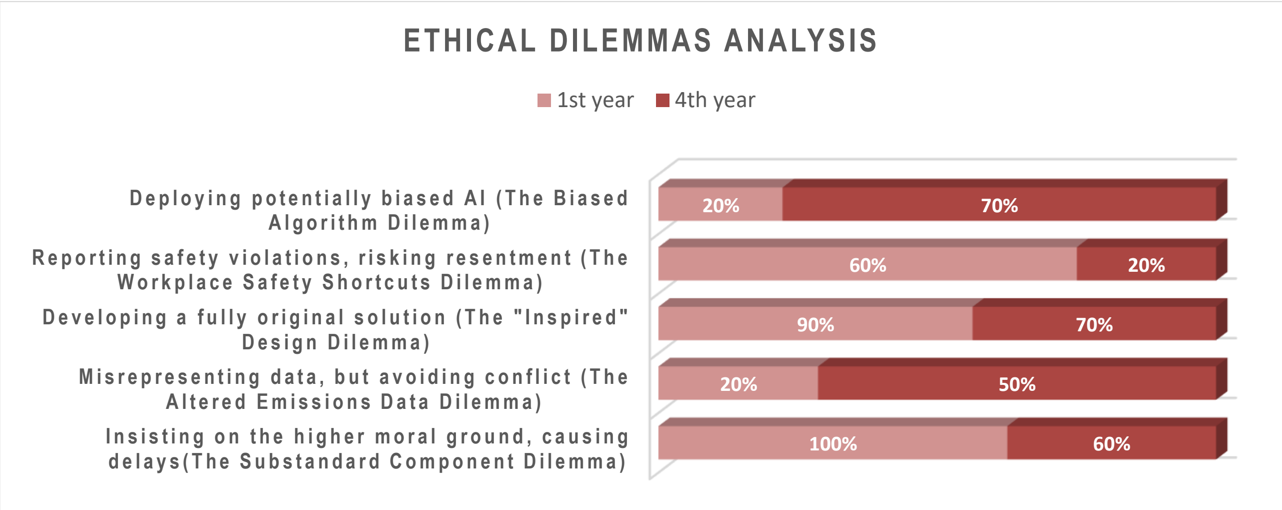

Fig. 3. Graphical representation of ethical dilemmas analysis

The «Workplace Safety Shortcuts Dilemma» provides stark evidence of how students learn to navigate organizational dynamics. The willingness to report safety violations plummets from 60% in the first year to just 20% in the fourth year. This demonstrates that senior students have become acutely aware of the personal risks associated with whistleblowing and are far less likely to challenge the status quo, aligning with the previous chart's finding of a perceived lack of engineer support. In summary, this data illustrates the «theory-practice gap» in action. Students enter their education with strong, clear-cut ethical principles. However, by the time they are ready to graduate, their perspective has been reshaped by an awareness of professional pressures, leading to a greater willingness to compromise on safety, misrepresent data, and stay silent about violations. This highlights a critical failure of current education to equip students with the skills and courage to uphold their initial ethical convictions in the face of real-world complexities.

At the same time, more seasoned students demonstrate a deeper understanding of complex contextual factors, moving beyond simplistic rule-following to consider stakeholder interests, societal impacts, and unspoken professional norms. This also typically correlates with a broader range of potential solutions considered, extending beyond immediate technical fixes to encompass communication strategies, policy adjustments, or long-term preventative measures. Consequently, the perceived weight of consequences tends to be more profound and far-reaching for experienced individuals, who are better equipped to anticipate cascading effects on public safety, environmental integrity, and professional reputation, unlike novices who might focus on more immediate or personal repercussions.

IV Discussion

Moving beyond purely theoretical instruction in engineering ethics towards more immersive, practice-oriented pedagogical approaches is profoundly important and seems like the only right step. While understanding ethical codes and philosophical principles provides a necessary foundation, it often fails to equip students for the ambiguous moral landscapes they will inevitably encounter in their careers. Immersive methods bridge this critical gap. These active learning strategies compel students to grapple with conflicting values, stakeholder interests, and the tangible consequences of their decisions.

By engaging in these practical exercises, aspiring engineers develop crucial critical thinking, moral reasoning, and communication skills under pressure. They learn to identify ethical issues proactively, analyze them from multiple perspectives, and articulate justifiable courses of action. Furthermore, such approaches foster a deeper sense of empathy and professional accountability, as students confront the human impact of engineering choices. This practical application helps internalize ethical principles, transforming them from abstract concepts into guiding tenets for professional conduct. Ultimately, this pedagogical shift not only teaches ethics but also aims to cultivate engineers with a robust ethical compass, prepared to uphold public safety, welfare, and the integrity of the profession. The recommendations below, based on the study results, ensure future engineers are not only technically proficient but also ethically astute, ready to make sound judgments in complex situations.

Implementing advanced *Case-Based Learning (CBL)* with complex and ambiguous scenarios will move beyond simplistic right-versus-wrong cases to those mirroring real-world professional life, characterized by incomplete information, conflicting stakeholder interests, significant uncertainties, and multiple viable (yet imperfect) solutions. Such scenarios integrate technical complexities with socio-ethical dimensions, forcing students to grapple with nuance [20].

Fostering *direct engagement with industry professionals* and incorporating structured interactions such as guest lectures by engineers sharing their ethical dilemmas, mentorship programs, site visits, and collaborative projects with industry or community partners. This provides students with firsthand accounts of organizational pressures and the practical application of ethical principles, as advocated in community-engaged learning approaches [21].

Employing *interactive role-playing and simulations* that design role-playing exercises where students adopt different stakeholder perspectives (e.g., project manager, junior engineer, client, regulatory body) in an ethical conflict can also be quite beneficial. Digital or virtual reality simulations [22] create immersive environments where students can make decisions under simulated pressures (like time, budget, authority) and experience their consequences in a safe space. Introducing students to various diverse established ethical theories (utilitarianism, deontology, virtue ethics, care ethics) and practical decision-making models encourages students to articulate their reasoning, justify their choices, and anticipate counterarguments.

It's imperative to cultivate a proactive, ethical mindset and professional identity in any student. *Regular reflective practice* encourages students to critically examine their values, biases, emotional responses to ethical dilemmas, and how these might influence their professional judgment and development of professional identity [10]. Explicitly discussing common pressures like conflicts of interest, loyalty dilemmas, obedience to authority, and groupthink equips students with strategies for ethical dissent, whistleblowing (and its protections or risks), and fostering ethical leadership within teams.

Longitudinal and horizontal ethics integration shifts from isolated ethics modules to weaving ethical considerations throughout the entire engineering curriculum, connecting them to technical subjects (e.g., safety factors in design, data privacy in software engineering, environmental impact in materials selection), reinforcing the idea that ethics is integral to engineering practice. University curriculum must be dynamic, incorporating contemporary issues and social justice implications of technology [23].

The dynamism of engineering ethics education is not only a response to changes within engineering itself but is also profoundly shaped by the evolving societal context in which engineering is practiced. Societal values, expectations, and challenges are not static; they shift over time, often in response to technological advancements, cultural movements, and global events. The sheer pace of technological change, typically described as exponential, means that new technologies with significant societal impact emerge faster than society can fully comprehend or develop ethical and regulatory frameworks for them. This requires engineers to engage in «anticipatory ethics» – to proactively consider the potential ethical implications of their work before technologies are widely deployed. The pervasiveness of technology, from smartphones to IoT devices, means engineering decisions have more intimate and widespread effects on daily life than ever before, heightening ethical scrutiny.

Engineering is an increasingly global profession. Engineers work on international projects, in multicultural teams, and for multinational corporations. This globalization brings them into contact with diverse cultural norms, legal standards, and ethical expectations [24]. What might be considered acceptable practice in one culture could be ethically problematic in another, so engineering ethics education must therefore equip students with cross-cultural competence and the ability to navigate these complex ethical terrains, understanding that universal principles may need culturally sensitive application. This involves grappling with ethical relativism versus universal ethical principles. There is a growing awareness of how engineering designs and technological systems can inadvertently (or sometimes intentionally) perpetuate or exacerbate social inequalities. Examples include biased algorithms in AI that discriminate against certain demographic groups [25] or infrastructure projects that disproportionately benefit affluent communities while disadvantaging marginalized ones. Engineering ethics is increasingly incorporating principles of social justice, calling for engineers to consider the equitable distribution of benefits and burdens of their work and to design for inclusivity [26]. As the realities of climate change, resource depletion, and biodiversity loss become more urgent, societal expectations for environmental responsibility also shift. This has moved sustainability from a niche concern to a central ethical imperative – the public increasingly demands that engineering solutions be environmentally sound, contributing to a circular economy and mitigating climate impacts. Modern advances in robotics, automation, and AI are poised to transform the labor market, potentially displacing large numbers of workers across various sectors. This raises profound ethical questions about economic disruption, social safety nets, the purpose of work, and the distribution of wealth generated by these automated systems [27]. Engineers developing these technologies are not isolated from these societal impacts. Ethical considerations include designing AI systems that augment rather than simply replace human capabilities, considering the retraining and societal adjustments needed, and engaging in public discourse about the future of work in an increasingly automated world.

The validity of the hypotheses proposed in the Introduction is strongly supported by the results of this study. Indeed, traditional ethics education, while strong in principle, demonstrably leaves a significant gap between theory and practice. It can be increasingly perilous amidst escalating pressures from technological acceleration, global competition, and complex organizational dynamics. Consequently, even 4th-year students are often ill-equipped to navigate the nuanced ethical dilemmas they encounter in their professional lives. Current pedagogical models (static presentation of the content of the codes of conduct and superficial consideration of known disasters) are confirmed to inadequately address the critical organizational, psychological, and systemic factors that heavily influence decision-making. Engineers often face conflicts between their professional duties, corporate pressures, and personal values, with no clear tools to resolve them. The direct result is an increased risk of public harm, environmental damage, and a significant erosion of trust in the profession. Therefore, the call to change engineering ethics education is not merely academic but an urgent professional necessity. Integrating methodologies such as CBL (Case-Based Learning), GVV (Giving Voice to Values), and active role-playing scenarios is therefore essential, as these are the very tools that cultivate engineers who possess not just theoretical knowledge but the practical wisdom and courage to apply ethical principles under real-world pressure.

V Conclusion

This study's empirical results confirm and quantify a deeply concerning trend: the systematic erosion of ethical commitment as student progress through their engineering education. The findings starkly illustrate that while students enter their studies with strong idealistic convictions, they graduate with a more cynical, pragmatic, and ethically flexible mindset. This is evidenced by a precipitous drop in their willingness to prioritize public safety over project constraints, a profound fear of whistleblowing, and a growing readiness to make unethical compromises such as misrepresenting data or deploying biased AI. This quantifiable decline directly validates the study's central hypothesis and goes beyond the widely accepted notion of a «theory-practice gap»; it charts the very process of its formation.

These findings directly refute the implicit theory that a knowledge-based education centered on abstract principles and codes is sufficient to ensure ethical practice. Instead, this research lends powerful support to theories from social psychology and organizational behavior, demonstrating that perceived situational pressures – such as lack of institutional support and fear of reprisal – are dominant factors in shaping professional ethical decision-making. The scientific novelty of this work lies in its empirical demonstration of this «ethical disillusionment», moving the academic discourse from a theoretical problem to a measurable educational failure. It advances scientific knowledge by showing that students are not merely becoming more «realistic» but are internalizing a sense of isolation and concluding that ethics is an individual burden rather than a shared professional responsibility.

The practical significance of these results is profound and urgent. They provide a clear mandate for a fundamental change from passive instruction toward active, experiential learning. To be effective, engineering ethics education must explicitly address and simulate the organizational and psychological pressures students will face. The results can be used to design curricula that integrate high-fidelity case studies, role-playing scenarios focused on navigating conflict, and strategies for building moral courage and ethical resilience. For future research, this study lays the groundwork for longitudinal studies to track the real-world behavior of graduates from these reformed programs and for comparative analyses across different institutional settings to refine these crucial pedagogical interventions further.

References

1. National Society of Professional Engineers (NSPE). (2019). NSPE Code of Ethics for Engineers. Retrieved from https://www.nspe.org/career-growth/nspe-code-ethics-engineers.
2. Petroski, H. (1985). To Engineer Is Human: The Role of Failure in Successful Design. St. Martin's Press.
3. Vaughan, D. (1996). The Challenger Launch Decision: Risky Technology, Culture, and Deviance at NASA. University of Chicago Press.
4. Harris, C. E., Jr., Pritchard, M. S., James, R.W., Englehardt, E.E., & Rabins, M. J. (2019). Engineering Ethics: Concepts and Cases (6th ed.). Cengage Learning.
5. Ewing, J. (2017). Faster, Higher, Farther: The Volkswagen Scandal. W. W. Norton & Company.
6. Baase, S., & Henry, T. M. (2017). A Gift of Fire: Social, Legal, and Ethical Issues for Computing and the Internet (5th ed.). Pearson.
7. O'Neil, C. (2016). Weapons of Math Destruction: How Big Data Increases Inequality and Threatens Democracy. Crown.
8. Whitbeck, C. (1998). Ethics in Engineering Practice and Research. Cambridge University Press.
9. Newberry, B. (2004). The dilemma of ethics in engineering education. Science and Engineering Ethics, 10(2), 343-351. DOI: 10.1007/s11948-004-0030-8.
10. Hess, J. L., & Fore, G. (2018). A systematic literature review of US engineering ethics interventions. Science and Engineering Ethics, 24, 551–583 (2018). DOI: 10.1007/s11948-017-9910-6.
11. Conlon, E., & Zandvoort, H. (2011). Broadening Ethics Teaching in Engineering: Beyond the Individualistic Approach. Science and Engineering Ethics, 17(2), 217–232.DOI: 10.1007/s11948-010-9205-7.
12. Hammar Chiriac, E. (2014). Group work as an incentive for learning – students' experiences of group work. Frontiers in Psychology, 5, 558. DOI:10.3389/fpsyg.2014.00558
13. Priliepo, N., & Borovyk, O. (2025). Facilitating first-year student adaptation through the study of "University Education". Visnyk Cherkaskoho natsionalnoho universytetu imeni Bohdana Khmelnytskoho. Seriia: «Pedahohichni nauky», 1, 58-64. DOI: 10.31651/2524-2660-2025-1-58-64.
14. The University of Alabama. (2023). Center for the Study of Ethical Development. Retrieved from https://ethicaldevelopment.ua.edu/about-the-dit/.
15. Davis, M. (1998). Thinking like an engineer: Studies in the Ethics of a Profession. Oxford University Press.
16. Bowman, S.L., & Lieberoth, A. (2018). Psychology and Role-Playing Games. In Zagal, José P. and Deterding, S. (eds.), Role-Playing Game Studies: Transmedia Foundations. New York: Routledge, 245-264. DOI: 10.4324/9781315637532-13.
17. Gentile, M. C. (2012). Giving Voice to Values: How to Speak Your Mind When You Know What's Right. Yale University Press.

18. ABET. (2024). Criteria for Accrediting Engineering Programs, 2025-2026. Retrieved from https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2025-2026/.
19. Milgram, S. (1974). Obedience to authority: An experimental view. Tavistock, London.
20. Zhu, Q., & Jesiek, B. K. (2019). Practicing Engineering Ethics in Global Context: A Comparative Study of Expert and Novice Approaches to Cross-Cultural Ethical Situations. Science and Engineering Ethics 26 (4):2097-2120. DOI: 10.1007/S11948-019-00154-8
21. Bielefeldt, A. R., Polmear, M., Knight, D., Swan, C., & Canney, N. (2019). Sustainable engineering ethics: Teaching sustainability as a macroethical issue. 2019 IEEE International Symposium on Technology and Society (ISTAS), 1-6. DOI: 10.1109/ISTAS48451.2019.8937862.
22. Nelson, M. E., & Ahn, B. (2018). Virtual Reality Activities for Teaching Engineering Students Professional Development Skills. 2018 IEEE Frontiers in Education Conference (FIE). DOI: 10.1109/FIE.2018.8659258
23. van de Poel, I. (2021). Design for value change. Ethics and Information Technology, 23, 27–31. DOI: 10.1007/s10676-018-9461-9.
24. Downey, G. L., Lucena, J. C., & Nichols-Belo, A. (2006). The globally competent engineer: Working effectively with people who define problems differently. The Research Journal of Engineering Education, 95(2), 107-122. DOI: 10.1002/j.2168-9830.2006.tb00883.x.
25. Noble, S. U. (2018). Algorithms of Oppression: How Search Engines Reinforce Racism. New York University Press. DOI: 10.2307/j.ctt1pwt9w5.
26. Riley, D. (2008). Engineering and Social Justice. Springer Cham. DOI: 10.1007/978-3-031-79940-2
27. Ford, M. (2015). Rise of the Robots: Technology and the Threat of a Jobless Future. Basic Books.

Прілєпо Наталія Володимирівна.
Старша викладачка кафедри механічної та електричної інженерії,
Полтавський державний аграрний університет,
вул. Сковороди, 1/3, м. Полтава, Полтавська обл., Україна, 36003.
E-mail: nataliia.pryliepo@pdau.edu.ua

Priliepo Nataliia Volodymyrivna.
Senior Lecturer of the Department of Mechanical and Electrical Engineering,
Poltava State Agrarian University,
vul. Skovorody, 1/3, Poltava, Poltava region, Ukraine, 36003.
E-mail: nataliia.pryliepo@pdau.edu.ua

ORCID: 0000-0002-4182-7405
Researcher ID: GRS-8058-2022

Боровик Олена Юріївна.
Асистентка кафедри механічної та електричної інженерії,
Полтавський державний аграрний університет,
вул. Сковороди, 1/3, м. Полтава, Полтавська обл., Україна, 36003.
E-mail: olena.borovyk@pdau.edu.ua

Borovyk Olena Yuriivna.
Assistant Lecturer of the Department of Mechanical and Electrical Engineering,
Poltava State Agrarian University,
vul. Skovorody, 1/3, Poltava, Poltava region, Ukraine, 36003.
E-mail: olena.borovyk@pdau.edu.ua

ORCID: 0000-0003-3115-7257

Citation (APA):
Priliepo, N., Borovyk, O. (2025). The Indispensable Imperative: Navigating the Evolving Landscape of Teaching Engineering Ethics in a Dynamic Societal Context. Engineering and Educational Technologies, 13 (2), 18–30. doi: https://doi.org/10.32782/2307-9770.2025.13.02.02

Цитування (ДСТУ 8302:2015):
Прілєпо Н. В., Боровик О. Ю. Необхідний імператив: пошук шляху у швидкоплинному ландшафті викладання інженерної етики в динамічному суспільному контексті / Інженерні та освітні технології. 2025. Т. 13. № 2. С. 18–30. doi: https://doi.org/10.32782/2307-9770.2025.13.02.02

Обсяг статті: сторінок – 13 ; умовних друк. аркушів – 1,883.