

# **ETHICS, AI, AND SOCIETY: SHAPING RESPONSIBLE AI ENGINEERS WITH CDIO FRAMEWORK**

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## **ABSTRACT**

This paper describes the development and implementation of a novel course entitled "Ethics, AI, and Society," designed within the CDIO framework to provide ethical education to Artificial Intelligence (AI) graduating engineering students. As AI technologies increasingly permeate various facets of society, the imperative for ethical acumen among engineers comes to the fore. In this regard, the module aims to equip AI engineering students with a holistic understanding of ethical dimensions, societal repercussions, and regulations associated with creating and implementing AI technologies. An interactive pedagogical strategy underpins the module, engaging students with a blend of theoretical discussions and experiential learning fostering a culture of critical thinking, collaboration, and lifelong learning. Building on this foundation, the course thoroughly explores philosophical basis and navigates a spectrum of real-world ethical dilemmas. Topics such as bias mitigation, data privacy, and the broader societal impacts of AI in various domains, including healthcare and economy, are explored in depth. The curriculum is further enriched by a series of diverse guest speakers, each hailing from unique professional background. These experts bring their distinctive perspectives and insights, thereby greatly enhancing the students' comprehension and engagement with the course material. This approach broadens the learning experience and deepens the understanding of the complex interaction between AI, ethics, and society. To ensure that this content leads to concrete learning outcomes and practical skills, the course's design and implementation strictly adhere to the CDIO standards. Preliminary feedback indicates a significant enhancement in students' capacity to tackle complex ethical dilemmas and an increased consciousness of the societal impact of AI. By presenting the course design, delivery methods, and initial outcomes, this paper aspires to serve as a guiding document for educators and institutions aiming to seamlessly integrate ethics into the foundation of AI engineering education.

## **KEYWORDS**

Ethical AI Education, CDIO standards, Engineering Curriculum, Critical thinking, Standards: 1, 2, 3, 7, 8, 11

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## **INTRODUCTION**

The integration of ethics in Artificial Intelligence (AI) is essential due to the complex nature of the field. In this regard this paper introduces a course that merges ethical principles with AI, aligned with the CDIO (Conceive-Design-Implement-Operate) educational framework. Highlighted by Dignum (2018), the ethical dimension is integral to AI development. The curriculum addresses this by incorporating the diverse ethical guidelines in AI, as explored by (Jobin et al, 2019), and the societal implications outlined by (Whittlestone et al. 2019). Governance issues, a crucial aspect of AI ethics discussed by (Cath, 2018), are also covered. This course aims to provide a comprehensive understanding of AI ethics, preparing future engineers to responsibly engage with AI technologies. This paper emphasizes a balanced curriculum that combines traditional engineering fundamentals with hands-on experience and real-world problem-solving (Crawley et al., 2014). In the context of AI, where ethical implications are as significant as technological innovations, the CDIO framework becomes particularly relevant. It ensures that future engineers are proficient in AI technologies and equipped to address the ethical dilemmas these technologies may present.

## **ETHICS IN HIGHER EDUCATION**

Academic institutions are increasingly integrating responsible AI education into their curricula, emphasizing the importance of preparing students for the ethical challenges posed by AI (Saad, M. 2023, Krakowski et al. 2022). This focus on shaping responsible AI engineers underscores the vital role of education in cultivating professionals ready to navigate the ethical complexities of AI in society. (Walsh et al., 2023) underscore the importance of tailored education for healthcare professionals, particularly in medical imaging, recognizing its pivotal role in enhancing transparency and understanding of AI tools. In (Tubella et al., 2024) paper, authors highlight the European Union High-Level Expert Group on AI's recognition of both opportunities and risks in AI. They stress the need for higher education to provide students with technical skills and an understanding of AI's ethical implications aligned with European values.

To this effect, a variety of pedagogical approaches have been employed, with several of them presented and studied by (Aközer et al., 2017) within the field of medical education. In this regard, we first mention the Case-Based Learning (CBL), and the Case-Based Reasoning (CBR) (McSharry, P. E., 2023, Antoniou, J., 2021) which are practical methods that have been used for teaching AI ethics. CBL involves analysing real-world AI ethical dilemmas, fostering discussions, and applying ethical theories to concrete situations. While CBR adapts past cases to new contexts, promoting critical thinking and problem-solving skills. Together, they create an interactive learning environment, equipping students with both theoretical knowledge and practical skills to navigate and address ethical challenges in AI. In addition to CBL and CBR, various pedagogical strategies contribute to a comprehensive AI ethics education (Aközer et al., 2017) and references therein for techniques overview).

## **ETHICS IN AI ENGINEERING**

The ethics of AI is a rapidly evolving field, critically important for engineers and developers. (Hagendorff, 2020) highlights the ineffectiveness of current AI ethics guidelines and stresses the need for more practical and enforceable standards, particularly in the engineering domain (Hagendorff, 2020). (Ryan, 2020) emphasizes the concept of trust in AI systems, advocating

for the development of trustworthy AI through ethical guidelines that ensure reliability and ethical compliance (Ryan, 2020). Furthermore, (Morley et al. 2021) bridge the gap between theoretical ethics and practical AI system design, proposing tools and methods that assist engineers in embedding ethical considerations into AI development (Morley et al., 2021). These perspectives underscore a shift in the AI field towards greater accountability and ethical responsibility, especially in the education and practice of AI engineering (Garrett, Beard, & Fiesler, 2020; Morley et al., 2020).

## COURSE DESCRIPTION

The course content, detailed herein, encompasses a series of specialized topics, each delivered through a two-hour remote interactive learning session by experts in their respective fields. The curriculum begins with an 'Introduction to Ethics in AI', laying a foundational understanding for the ethical considerations critical in AI applications. It progresses to 'Foundations of Ethical Thinking', offering a philosophical base for ethical decision-making in the context of AI. 'Bias, Fairness, and Discrimination in AI' addresses the challenge of creating equitable AI systems, while 'Privacy and AI' focuses on the essential aspects of data privacy. The course also covers 'Autonomous Systems and Accountability', highlighting the responsibilities associated with autonomous AI technologies. Broader societal implications are explored in 'AI, Employment, and Economy', and 'AI in Healthcare, Security, and Warfare', examining the impact of AI on these vital sectors. 'Regulating AI: Governance and Policies' explores the governance frameworks necessary for ethical AI development and usage. The course culminates with a module on 'Case Studies: Ethical Dilemmas in AI Deployments', where practical scenarios are analysed to understand the real-world complexities of AI ethics. The paper underscores how this course, rooted in the CDIO framework, aims to equip learners with a holistic and in-depth understanding of the ethical challenges and considerations in the AI and societal interface.

## SYLLABUS OUTLINE

Table 14. Syllabus outline

Session	Topic	Content
1	Introduction to Ethics in AI	<ul style="list-style-type: none"> <li>Importance of ethics in AI</li> <li>Historical context: from Asimov's laws to modern dilemmas</li> </ul>
2	Foundations of Ethical Thinking	<ul style="list-style-type: none"> <li>Philosophical foundations: utilitarianism, deontology, virtue ethics, etc.</li> <li>The trolley problem and its variants in AI</li> <li>Ethical frameworks and their applicability to AI</li> </ul>
3	Bias, Fairness, and Discrimination in AI	<ul style="list-style-type: none"> <li>Understanding bias: origins and implications in datasets</li> <li>Algorithms and their inadvertent consequences</li> <li>Strategies to mitigate bias and promote fairness</li> </ul>
4	Privacy and AI	<ul style="list-style-type: none"> <li>Data collection, consent, and surveillance</li> <li>Privacy-preserving AI techniques</li> <li>GDPR, CCPA, and other regulations affecting AI</li> </ul>
5	Autonomous Systems and Accountability	<ul style="list-style-type: none"> <li>Self-driving cars, drones, and decision-making systems</li> <li>Liability and accountability in AI errors</li> <li>The challenge of explainability and interpretability</li> </ul>

<b>6</b>	AI, Employment, and Economy	<ul style="list-style-type: none"> <li>• Impact of AI on jobs: displacement and creation</li> <li>• Economic consequences: inequality and new economic models</li> <li>• Reskilling, lifelong learning, and the future of work</li> </ul>
<b>7</b>	AI in Healthcare, Security, and Warfare	<ul style="list-style-type: none"> <li>• Ethical considerations in AI-driven diagnostics and treatments</li> <li>• Surveillance systems, facial recognition, and civil rights</li> <li>• Autonomous weapons and the future of warfare</li> </ul>
<b>8</b>	Regulating AI: Governance and Policies	<ul style="list-style-type: none"> <li>• Current international policies and regulations on AI</li> <li>• The role of global institutions, governments, and corporations</li> <li>• Prospects and challenges in AI governance</li> </ul>
<b>9</b>	Case Studies: Ethical Dilemmas in AI Deployments	<ul style="list-style-type: none"> <li>• Analysis of real-world scenarios where AI ethics came to the forefront</li> <li>• Discussion of the decisions made and their consequences</li> <li>• Lessons learned and best practices</li> </ul>
<b>10</b>	Course Wrap-Up and Forward-Thinking	<ul style="list-style-type: none"> <li>• Group projects: Proposing ethical guidelines for a specific AI application</li> <li>• Exploring the future challenges of AI in society</li> <li>• The role of AI engineers in shaping an ethical future</li> </ul>

## ALIGNING AI ENGINEERING ETHICS WITH CDIO STANDARDS

The course design and implementation strictly adhere to the CDIO standards (Malmqvist et al., 2019). This alignment begins with Standard 1, connecting AI engineering with real-world ethical and societal considerations. It defines clear Intended Learning Outcomes (Standard 2) that ensure a rounded development of competencies. The integrated curriculum design (Standard 3) merges theoretical knowledge with practical applications, enhancing students' ability to apply ethical principles in tangible scenarios. In line with Standard 7, the course weaves technical knowledge with interpersonal skills development, with a strong emphasis on ethical practices in AI. Active learning is central to the course format (Standard 8), with discussions, case studies, and projects fostering an engaging and participative educational environment. Lastly, the course employs assessment methods (Standard 11) that evaluate students on their CDIO skills, particularly their ability to critically engage with real-world AI challenges and formulate appropriate ethical guidelines.

## ANALYSING STUDENT FEEDBACK

The survey methodology involved a class of 36 students enrolled in the 'Ethics, AI, and Society' course. Of these, 31 students participated in the survey, yielding a response rate of approximately 86%. The survey was administered using Google Forms, ensuring ease of access and efficient data collection. The questionnaire was designed to encompass a mix of binary questions, Likert-scale questions for quantifiable feedback, and open-ended questions to capture detailed qualitative insights, thereby providing a comprehensive evaluation of the course from multiple perspectives.

### **Quantitative analysis**

The survey data focuses on several key aspects of the "Ethics, AI, and Society" course. The numerical ratings section of the survey utilizes a Likert scale ranging from 1 (indicating the worst evaluation) to 5 (representing the best evaluation). The quantitative analysis of the survey data for the "Ethics, AI, and Society" course reveals the following insights:

Table 15. Quantitative analysis of students Feedback

	Mean Rating	Standard Deviation	Ratings range
<i>Effectiveness of Online Lectures</i>	Approximately 3.65 out of 5	0.79, indicating moderate variability in student responses	from 2 to 5, suggesting diverse opinions on the effectiveness of online lectures.
<i>Beneficial Nature of Discussions and Case Studies</i>	Around 4.24 out of 5.	0.75, showing relatively consistent positive feedback.	from 3 to 5, indicating generally high appreciation for discussions and case studies.
<i>Contribution of Guest Speakers</i>	Approximately 4.35 out of 5.	0.61, suggesting a high level of satisfaction with guest speakers.	from 3 to 5, with most responses skewing towards higher satisfaction.
<i>Effectiveness of Assessment Methods</i>	About 4.06 out of 5.	0.75, reflecting a fairly consistent positive view.	from 3 to 5, indicating overall effectiveness but with room for improvement.
<i>Overall Satisfaction with Feedback</i>	Around 4.06 out of 5.	0.75, showing a strong level of satisfaction among most students	range from 2 to 5, with most students feeling satisfied

**Interpretation and Recommendations:**

*The effectiveness of online lectures* is viewed positively but with notable room for improvement. Engaging delivery methods and interactive content could enhance this aspect.

*Discussions and case studies* are highly valued, indicating their importance in understanding AI ethics. This method should be continued and possibly expanded.

*The guest speakers* made significant positive contributions. Continuation of this approach and possibly involving a broader range of speakers could be beneficial.

*Assessment methods* are generally effective, but exploring varied or additional assessment formats might further enhance learning outcomes.

*Feedback satisfaction* is high, emphasizing the importance of maintaining quality feedback mechanisms.

These insights can be instrumental for the continuous improvement of the course, ensuring it aligns with the CDIO framework and effectively imparts ethical education to AI engineering students.

### ***Qualitative Analysis of "Ethics, AI, and Society" Course: Student Perspectives and Recommendations***

This section of the academic paper presents a qualitative analysis of the survey responses regarding the "Ethics, AI, and Society" course, focusing on the students' perspectives on various aspects of the course.

#### *Engaging Topics and Content Gaps*

*Engaging Topics:* Students expressed diverse interests, with topics like "Bias, Fairness, and Discrimination in AI," "Ethics," and "AI in Warfare" being highlighted. One student notably mentioned, "The ethics topic is a crucial subject that we usually overlook in our studies."

*Content Gaps:* While many students were satisfied, some suggested areas for expansion, such as "understanding more how ethics are translated into laws" and exploring "the evolution of AI and Ethics in 10 years."

#### *Influence on Perception of Societal Impacts*

Students acknowledged a significant shift in their perception of AI's societal impacts. One respondent stated, "It made me look with a different angle for the use of AI in society," illustrating the course's effectiveness in broadening perspectives.

#### *Application to Case Studies*

Responses indicated practical application of learned concepts. For instance, a student described applying "ethical principles and considerations to an AI-powered healthcare system," showcasing the course's impact on real-world problem-solving skills.

#### *Assessment Methods*

Suggestions for improvement in assessment methods varied. Some students were content, calling it "the best way," while others proposed ideas like "anonymous peer review" and "more guest evaluations."

#### *Most Liked Aspects*

The diversity of the course and its interactive nature were frequently mentioned. One student highlighted, "The numerous points of view from different teachers was enriching."

#### *Areas for Improvement*

Recommended improvements included more practical homework, consistent course content, and regular discussion sessions, indicating a desire for deeper engagement and uniformity in course delivery.

### *Additional Comments*

A mix of appreciation and constructive feedback was evident. One student suggested, "The course lessons must be conducted in person," emphasizing the value of face-to-face interactions.

### *Insights and Recommendations for Course Enhancement*

The qualitative analysis of the 'Ethics, AI, and Society' course shows its effectiveness in engaging students with diverse AI ethics topics and enhancing their understanding of AI's societal impacts. While it equips students for ethical decision-making, improvements are needed in content depth, assessment methods, and course consistency. These findings, supported by student quotes, highlight areas for course refinement and its role in advancing ethics in AI engineering education.

### **Synthesis Evaluation of "Ethics, AI, and Society" Course**

The present table summarises the students feedback in key insights and paths to enhanced delivery.

Table 16. Feedback Synthesis

	<b>Topic</b>	<b>Students Feedback</b>
Key Insights	Content Relevance	Predominantly perceived as 'Very relevant' to AI engineering studies, indicating strong alignment with educational objectives
	Preparedness for Ethical Dilemmas	Majority of students feel better equipped to handle ethical issues in AI post-course, reflecting practical efficacy.
	Engagement and Diversity	Varied topics like bias in AI and AI ethics in warfare captivated student interest, highlighting the course's diverse and engaging curriculum.
	Perception Shift	Significant impact on students' perspectives regarding the societal implications of AI, fostering a broader and more critical understanding.
	Practical Application	Evident in case studies where students applied ethical principles to real-world scenarios, demonstrating the course's success in merging theory with practice.
	Assessment Methods	Generally effective but with suggestions for anonymity in peer reviews and more varied guest evaluations.
	Expand Content Scope	Integrate emerging topics and deeper explorations into the practical implications of AI ethics.

<i>Paths to Enhanced Delivery</i>	Increase Interactive Elements	Encourage more active student participation and discussions to deepen engagement.
	Consolidate Course Consistency	Ensure uniformity in content delivery across different modules for a more cohesive learning experience.
	Refine Assessment Methods	Incorporate a broader range of evaluation techniques, including anonymous peer reviews and diverse expert assessments.
	Strengthen Practical Applications	Further emphasize the application of ethical principles in tangible, real-world situations.

## CONCLUSION

The course "Ethics, AI, and Society" effectively combines ethical theory with practical AI applications, enhancing AI engineering education within the CDIO framework. It has shown success in improving students' understanding and handling of ethical issues in AI. Student feedback indicates strong engagement and learning outcomes, with suggestions for future improvements in content and assessments. This course model can serve as a scalable template for similar educational programs. Ongoing research into the long-term effects of such courses on AI practices and societal impacts is recommended. This educational initiative is a crucial step towards integrating ethical considerations into the rapidly evolving field of AI.

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