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Teaching Data Ethics and Privacy: Strategies for Data Science Programs

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Abstract. *The acceleration of digital transformation, Big Data analytics, and Artificial Intelligence (AI) implementation has fundamentally reshaped operational landscapes across sectors, ranging from academic governance to MSME commercialization. However, this technological leap has triggered unprecedented crises in information ethics, privacy breaches, and massive data secuSrity vulnerabilities. This article aims to synthesize theoretical foundations, global bibliometric research trends, field-level security challenges, and interdisciplinary pedagogical strategies based on state-of-the-art literature. By integrating the concept of Distributed Moral Responsibility (DMR), large-scale global bibliometric trend analysis, technical risk evaluations (such as national ID card leaks and e-commerce breaches), and top-to-bottom capstone-integrated curricula, we formulate a responsive data governance framework. This paper asserts that enforcing data ethics requires a synergistic alignment between regulatory compliance (such as the Personal Data Protection Act/UU PDP), secure technical architectures, and the reconstruction of transversal higher education curricula.*

Keywords: Data Ethics; Information Privacy; Cyber Security; AI Governance; STEM Pedagogy.

INTRODUCTION

Data privacy as a subject of study and practice is relatively young; in particular, many of the techniques used for data protection are still evolving (Venkataramanan & Shriram, n.d.). Ethics create the foundation for healthy and harmonious social interactions, ensuring that individuals can live together with respect for other's rights and values (Putri et al., 2025). Advances in digital technology have enabled the collection and exploitation of personal data on an unprecedented scale (Zuboff, 2019)(Fatimah et al., 2025). Ethics in the context of information technology relates to moral values that regulate the behavior of stakeholders (users, developers, organizations) so that the use of technology does not harm other parties (Suarantalla, 2025) .

In the context of IT professional ethics, information security must be understood through the CIA Triad framework: Confidentiality, Integrity, and Availability (No et al., 2026). Some major cases that have attracted public attention include the data leak of 1.3 billion Indonesians from the National Data Center (PDN) in 2024, the data leak of e-commerce and online transportation application users, and various online fraud cases that exploit weaknesses in digital security systems (Hardiansyah et al., 2026). Data extracted from social networks is analyzed using various algorithms to identify hidden relationship patterns, behavioral trends, and community structures(Fadhilah, n.d.). the increasing use of data on a large scale raises concerns regarding the protection of personal data(Petisi, 2026). For digital HR, organizations need

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to have clear policies and procedures. Data use must comply with applicable privacy regulations, such as the Personal Data Protection Act. (Penelitian & Riset, 2023). To handle diverse measurements of big data in terms of volume, velocity, and variety, there is need to design efficient and effective frameworks to process expansive measure of data arriving at very high speed from various sources. Big data needs to experience multiple phases during its life cycle(Jain et al., 2016).

LITERATURE REVIEW

Concept and Dimensions of Data Ethics

Data ethics is an interdisciplinary framework that evaluates the moral implications of data collection, processing, and deployment. While early definitions focused strictly on legal data compliance and cybersecurity safeguards, contemporary perspectives highlight systemic fairness, data transparency, and human autonomy. It functions as a socio-technical ecosystem requiring collaboration across computer science, philosophy, and legal disciplines.

Current Status of Data Science Curricula

Globally, technical readiness in education has seen massive investments. Universities have successfully integrated complex big data engineering, cloud computing, and advanced machine learning models into their core tracks. However, the pedagogical translation of ethical theory into technical execution remains fragmented. Smaller or newly established departments frequently struggle with severe curriculum constraints, lacking the specialized faculty required to bridge the gap between technical code and abstract philosophy.

Opportunities in Ethical Tech Education

The current societal shift provides significant opportunities to reform computing education:

- **Regulatory Momentum:** Global frameworks (such as GDPR or local personal data protection laws) act as practical catalysts, forcing academic institutions to align training with professional compliance realities.
- **Open-Source Ethical Frameworks:** The rise of algorithmic auditing tools, bias-detection libraries, and open-access case repositories provides concrete teaching aids.
- **Student-Driven Demand:** Modern learners exhibit high interest in tech-governance and corporate social responsibility, increasing classroom engagement.

Challenges in Implementation

Despite these driving factors, computer science departments face strict structural boundaries:

- **The "Technical Bias" Gap:** Curricula are heavily optimized for computational efficiency and speed, often treating ethical reflection as a secondary, non-technical elective.
- **Human Resource Constraints:** A shortage of interdisciplinary professors capable of teaching both rigorous statistical modeling and socio-political theory.
- **Measurement & Standardization:** Unlike compiler optimization or mathematical proofs, "fairness" and "ethical stance" cannot be evaluated with binary grading metrics, causing pedagogical ambiguity.

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Research Gap

While numerous studies examine the philosophical importance of AI ethics, previous research remains case-specific or highly abstract. Existing literature tends to analyze pedagogical philosophy separately from technical data pipeline execution. This study seeks to bridge this gap by offering a holistic, integrated framework that simultaneously addresses educational driving forces, infrastructural hurdles, and concrete classroom execution.

Conceptual Framework

This conceptual model treats data science education as an integrated system centered on the interaction of key pillars: Technical Agility, Legal Literacy, Algorithmic Responsibility, and Public Advocacy.

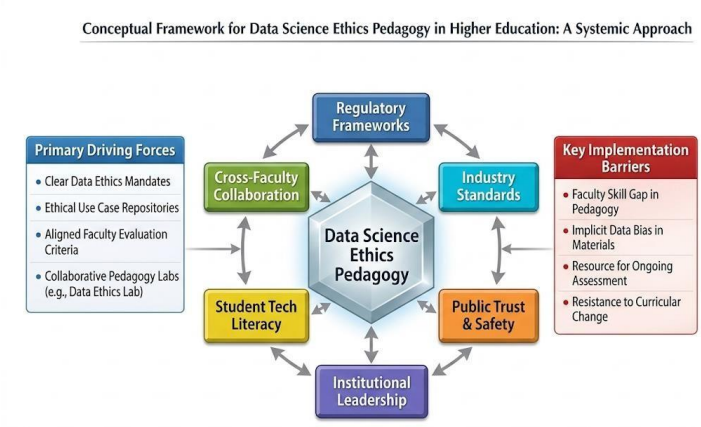

Figure 1 : Conceptual Framework for data scince Ethics pedagogy in Higher Education A Systemic Approach

METHODS

Research Design

This study adopts a qualitative-descriptive approach using a multiple-case study strategy to explore how distinct Data Science and Information Technology faculties deploy data ethics instruction. A qualitative framework is optimal for mapping the nuanced intersections of institutional policy, educational pedagogy, and cultural readiness within STEM departments.

Data Collection Methods

The study utilizes secondary data sources as its primary baseline, synthesizing:

- National educational directives, computing association curricula guidelines, and university syllabus documents.
- Academic journals covering computing education, data ethics pedagogy, and technology governance.
- Case studies and instructional reports from global and domestic institutions specializing in data-driven education.

Data Analysis Technique

Data were evaluated using thematic analysis to identify explicit structural patterns in educational execution. Findings are interpreted through an analytical framework approach utilizing four core constructs:

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- **Driving Factors:** External regulatory pressures, availability of bias-detection tools, and student interest.
- **Challenges:** Curriculum overload, rigid grading systems, and interdisciplinary silos.
- **Moderating Factors:** Institutional leadership, cross-departmental communication, and funding for pedagogical innovation.
- **Outcomes:** Students' ability to run algorithmic audits, construct privacy-by-design architectures, and exercise critical systemic thinking.

RESULTS AND DISCUSSION

Overview of Educational Practices

The analysis shows an uneven distribution of data ethics training. Elite institutions and dedicated tech universities often possess structured data governance tracks, deploying advanced interactive software and industry-sponsored toolkits. Conversely, smaller departments frequently rely on passive, lecture-only formats or condense all ethical concepts into a single, generic introductory module.

Analysis of Primary Enablers (Driving Factors)

The integration of concrete programming toolkits (e.g., open-source bias metrics, cryptographic privacy libraries) acts as a critical enabler. When data ethics is framed as an engineering challenge—such as debugging algorithmic bias or executing differential privacy calculations—student retention and technical alignment improve dramatically.

Structural Barriers

The greatest barrier remains institutional silos. Computer science tracks operate under strict credit-hour ceilings, prioritizing algorithmic speed and deployment architectures. Faculty members often express discomfort evaluating subjective social impacts, resulting in a teaching style that minimizes data governance in favor of pure technical performance.

The Influence of Moderating Factors

The presence of supportive institutional leadership and flexible curriculum frameworks acts as a powerful moderating force. Departments that foster direct, cross-disciplinary alliances—allowing philosophy or legal scholars to co-teach data mining labs—consistently produce students with a higher capacity to handle real-world deployment risks.

Pedagogical and Professional Outcomes

When programs successfully implement this dual-track model, professional outcomes improve significantly. Graduates display a strong capacity for "privacy-by-design" software construction, reducing corporate liability and building data platforms that actively earn public trust.

Discussion

Ultimately, data science education must move past the false dichotomy of technical training versus philosophical reflection. Effective education requires an adaptive, holistic approach that treats ethical assessment as a fundamental metric of software quality, alongside computational speed and model accuracy.

Analysis Component	Current Landscape & Structural Barriers	Solusi & Faktor Pendukung (*Enablers*	Solutions & Primary Enablers
Educational Practices *(Current State)*	**Curricular Disparity:** Elite institutions deploy structured data governance tracks with advanced software. Smaller departments rely on passive, lecture-only formats or	Move away from passive lecturing. Transition smaller departments toward active, hands-on framework integration.	Move away from passive lecturing. Transition smaller departments toward active, hands-on framework integration.

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	condense ethics into a single generic module.		
Primary Enablers *(Driving Factors)*	Ethics is often perceived by technical students as purely philosophical, abstract, or a matter of rote memorization, leading to low retention.	Framing as an Engineering Challenge: Integrate concreteprogramming toolkits (e.g.,open-source biasmetrics, cryptographic privacy libraries) directly into core labs.	Student retention and technical alignment improve dramatically because they practice it as "debugging algorithmic bias."
Structural Barriers *(Core Hurdl \es)*	**Institutional Silos:** Strict credit-hour ceilings prioritize algorithmic speed and deployment. Faculty members often express discomfort evaluating subjective social impacts.	Provide flexible curriculum spaces and specialized adaptive training to equip technical professors with ethical vocabulary and methods.	Ethics is no longer minimized or sidelined in favor of pure technical performance.
Influence of Moderating Factors *(Catalysts)*	Rigid departmental structures and institutional bureaucracy block collaboration between technical and non-technical fields.	**Supportive Leadership & Flexibility:** Foster direct, cross-disciplinary alliances, allowing philosophy or legal scholars to co-teach data mining labs.	Graduates develop a significantly higher capacity to anticipate and handle real-world deployment risks.
Pedagogical & Professional Outcomes	Traditional legacy programs produce graduates who are technically proficient but blind to legal, privacy, and systemic bias risks.	Successfully implement the **Dual-Track Model** that treats ethical assessment as a fundamental metric of software quality.	**Privacy-by-Design:** Graduates construct software that reduces corporate liability and builds data platforms that earn public trust.

Table 1. Strategic Overview of Educational Practices, Barriers, and Outcomes in Data Ethics

TABLE 1. Table information

Based on the structural analysis presented in Table 1, the integration of ethical considerations within technological and data science education requires a fundamental paradigm shift away from traditional, isolated pedagogical models. Current academic structures often relegate ethical frameworks to passive, lecture-only odules, creating significant curricular and institutional barriers that detach socio-ethical responsibilities from technical execution. To overcome these constraints, a comprehensive framework must leverage specific driving factors and crossdisciplinary catalysts. By dismantling rigid departmental silos

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and fostering flexible leadership alliances—such as co-teaching initiatives between technical professors and humanities scholars—institutions can successfully transition toward hands-on, project-based laboratory integration. Ultimately, embedding ethical debugging directly into core technical exercises cultivates a "Privacy-by-Design" competency, producing highly skilled graduates who are systematically equipped to mitigate algorithmic biases and build public trust in real-world system deployments.

CONCLUSIONS

This study demonstrates that embedding data ethics and privacy into Data Science programs is a systemic necessity driven by changing regulatory landscapes and evolving industry realities. Success depends on moving away from passive, isolated lectures toward an integrated, hands-on framework where algorithmic responsibility is built directly into core technical labs.

Recommendations for Data Science Programs

1. **Embed Applied Labs:** Integrate real-world case studies and bias-detection exercises directly into standard programming, database, and machine learning labs rather than separating them into elective courses.
2. **Foster Interdisciplinary Co-Teaching:** Build structural alliances between Information Technology faculties, humanities departments, and legal experts to co-design and deliver data governance courses.
3. **Adopt Privacy-by-Design Standards:** Require students to construct clear data-minimization, encryption, and consent architectures as mandatory evaluation metrics for capstone software and graduation projects.
4. **Develop Adaptive Faculty Training:** Invest in specialized training programs to equip technical professors with the vocabulary and methods needed to guide discussions on systemic bias, data ethics, and AI regulation.

RECOMMENDATIONS

1. Universities need to integrate data ethics and privacy into core Data Science courses, not just as electives or supplemental material. This approach will help students understand that ethical aspects are a crucial part of data processing and technology development.
2. Hands-on learning methods need to be expanded, such as the use of data breach case studies, algorithm bias audits, and privacy breach simulations. This approach can improve students' ability to deal with real-world problems.
3. Cross-disciplinary collaboration needs to be strengthened between study programs in information technology, law, and social sciences. This collaboration can result in more comprehensive learning regarding the technical, legal, and social aspects of data management.
4. Educational institutions need to provide specific training for lecturers on data ethics, privacy, and artificial intelligence (AI) regulations. This way, lecturers will have sufficient competency to teach evolving ethical issues.
5. Privacy-by-Design standards need to be implemented in students' final projects, so that every system or application development considers personal data protection from the design stage, not after the system is completed.
6. Further research is recommended to conduct empirical studies directly on students and lecturers of the Data Science Study Program, so that a more accurate picture can be obtained regarding the effectiveness of the data ethics and privacy learning strategies that have been implemented.
7. Evaluation of data ethics competency needs to be developed in a more measurable way, for example through project assessment, case study analysis, and critical reflection of students, so that ethical abilities are not only measured through theoretical exams.

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8. Universities need to adapt their curriculum to the latest regulatory and technological developments, such as the Personal Data Protection Law (PDP Law), AI Governance, and evolving cybersecurity challenges.

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