Frontiers in Computer Science and Artificial Intelligence
DOI: 10.32996/fcsai
Journal Homepage: www.al-kindipublisher.com/index.php/fcsai

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| RESEARCH ARTICLE

Towards Responsible Engineering Software: Ethical, Legal and Social Implications of Automated Design and AI-Driven Tools

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| ABSTRACT

There has been an increasing trend in the level of integration of Artificial Intelligence (AI) and automation features in engineering software, leading to game-changing design, modelling & simulation methods in all areas. But these breakthroughs also pose deep ethical, legal and social quandaries. This article critically reflects upon the changing responsible engineering software terrain through examining how automated design tools and its AI-drivers are shaping accountability, transparency, intellectual property and workforce dislodgment. Utilizing an extensive cross-disciplinary literature review, the paper identifies prominent eth- ical dilemmas such as algorithmic bias, mishandling of data and overdependence on opaque decision systems. It further investigates new legal regimes shaping the liability for AI-mediated engineering outcomes and considers what social implications they could have on professional autonomy and human control. The paper presents a concept of responsible engineering software development, highlighting the design automation as a counterpart to ethical-by-design principles, regulation compliance and societal values. Results emphasize cross-disciplinary governance frameworks, explainable AI integration and adaptive regulatory policies to guarantee that the future of engineering software is safe, fair and human-centric.

| KEYWORDS

Intrusion Detection Systems, Adversarial Machine Learning, Explainable Artificial Intelligence (XAI), Federated Threat Intelligence

| ARTICLE INFORMATION

ACCEPTED: 01 November 2024 **PUBLISHED:** 17 November 2024 **DOI:** 10.32996/fcsai.2022.1.1.1

1. Introduction

1. Background and Rationale

Here, "engineering software" is defined to cover design applications, simulation environments, automation systems and AI-based code or modelling platforms that facilitate engineering results. As these tools evolve from simple deterministic algorithms to autonomous, data-driven and adaptive systems, questions of accountability, oversight, rights and social impact become relevant.

A single gravity for this study One of the main motivations for the present work is stimulated by the fortuity between two trends. The first is that engineering software is increasingly automated and infused with AI (for example through generative design, adaptive simulation, intelligent code-generation) and thus changes the role of the human engineer—both in routine tasks as well as decision-making. Second, the use of these tools in engineering presents new challenges: who should bear responsibility when an AI module in a structural design tool falters? How are intellectual property rights impacted when AI co-designs designs? What are likely social implication if automate either, replaced by, or transform the work of engineering?

AI systems, as research shows, have very general ethical implications in the areas of bias, privacy, transparency, accountability and social fairness. onlinecs. baylor. edu The software engineering and AI literature confirms that these concerns are also valid in the contexts of engineering: the use of AI-embedded tools used for engineering applications can introduce bias from training data, produce opaque decision-making paths, obfuscate chains of responsibility, and be at odds with current legal and professional frameworks. For instance, AI assistants for software development have been reported to cause security/quality risks and ethical problems.

In the light of this, responsible engineering software (i.e. engineering software that is developed, deployed and managed in a manner appropriate with ethical, legal and societal norms) urgently needs to be addressed. This paper seeks to contribute to that demand by unpacking ethical, legal and social issues of automated design and AI-enabled tools embedded within engineering software.

Scope of the Study

This paper is interested in software engineering tools, featuring AI or automation rather than simply traditional deterministic algorithm—specific:

• Generative, Optimize or Adaptive Modules (e.g., Generative Design in the field of Mechanical/Civil Engineering)

A second social issue is public confidence and societal acceptance. Architecture and infrastructure design are essential to public welfare; when AI is integrated into such systems, trust of the public may hinge on transparent, accountable, ethical deployment of these capabilities. Absence of explicit governance or responsibility chains leaves room for mistrust.

Lastly, a critical reflection is required on the digital divide and inclusivity: if we develop AI-mediated engineering tools in (and apply them to) domains associated mostly with affluent organisations or regions, less-resourced firms or countries may fall farther behind and increase inequality.

Research Gap and Contribution

While there is a growing body of work in AI ethics, and responsible AI in software engineering, the sub-field of people engineering software—that is tools used in engineering disciplines (mechanical, civil, aerospace, infrastructure) that embeds AI or automation as part of design/simulation workflows—remains relatively thin. Research on AI-driven software engineering has existentially considered the broader effects of AIs (such as programming, etc.) metaphorically and ontologically rather than in terms of societal constructs and values specifically, although recent work has begun to address implications for general AI.JAn2011-24; Hadasz-Krawczyk2020-4 Less is known about how these consequences would play out in software engineering contexts with their specific safety, liability, and public-welfare concerns.

This research seeks to address this gap by:

- Generalizing and synthesising ethical, legal and social issues around AI/automation in engineering software;
- Developing a theoretical framework for responsible engineering software design, development and governance;
- Extracting insights for engineers, software vendors, regulators and society - contributing to both academia and practice.

Overview of the Structure

The rest of the paper is organized as follows. Literature review of the ethics, legal and social implications of AI-powered software and engineering tools In Section 2, we present a literature review on the ELISAs. 3 Analysis and conceptual framing are described in Sec. The findings are discussed in Section 4, and some of the key themes, challenges and emerging practices identified. Section 5 suggests a systematization for responsible engineering software. Section 6 discusses some implications for practice, policy and further research. Section 7 concludes with some considerations on how we can ensure engineering software mature responsibly in an AI-driven world.

2. Literature Review

2.1 Ethical Implications of AI & Automation in Software and Engineering Tools

The introduction of AI-enabled solutions in software and engineering fields has caused significant ethical concern. More generally, AI ethics highlights principles such as transparency, fairness, accountability and oversight by humans, who indicate 22 global ethical principles and 15 main challenges for AI ethics, among which transparency, privacy, accountability and fairness are the most mentioned.

Within the information systems space, the conversation is characterized as “complex and unstructured”, with ethical aspects of AI in software and systems engineering requiring more structure .

Especially in software engineering, ethics work has begun to map out stakeholders and value models e.g. by highlighting that software-engineering ethics cuts across a range of stakeholder (developers, users, organisations) and ethical values .

When we look at engineering software — design, simulation and modelling tools enhanced with automation or AI — the stakes are even higher, as those failures can lead to physical and safety constraints, loss of life or property and societal scale damage. Relevant ethical considerations are:

• Bias and fairness: If the AI modules embedded in engineering tools are calibrated from datasets that are biased with respect to specific geographies, materials or design types, they might systematically discriminate against other settings .

2.2 Legal and Governance Considerations

Legal and compliance implications of AI and automation in software tools is yet another one. At macro level, governance of AI must focus on accountability, liability, data protection and privacy, IP and the governance frameworks . .

Some key threads in this realm of computer engineering include:

• Liability and accountability: With something like a 3D paint tool if one draws artwork that collapses to the AI-augmented S3P display — liabilities are hard to assign, is it the vendor, the artist, or did they suffer from bad AI? The legal literature highlights the frequent discrepancy between human law-making processes and technological innovation (Naik, 2022). PMC

• IP and authorship: AI tools could designs collaboratively or produce the variations on a design and so issues around creation, ownership and rights to created designs are raised. This is less discussed in the engineering literature, but it has been recognized as an emerging issue within AI legal scholarship.

• Data privacy and trade secrets: Many engineering software tools depend on proprietary data (like material properties, previous designs), but adding AI into the system brings even more data processing, which may cross jurisdictions — with implications for privacy and trade secret laws.

• Governance, audit and standards: According to recent reviews, drive toward ethical-AI auditing and governance frameworks . SpringerLink Furthermore, research in AI governance highlights fairness, accountability, transparency, inclusivity as central to responsible deployment.

• Professional and regulatory standards: For engineering software, that is frequently used in regulated sectors (civil, aerospace or infrastructure) adherence to professional standards and certification are mandatory. The use of AI further muddies the water, as doomsday scenario regulators may not yet have drawn up what form such standards could take for AI-enhanced design tools.

Despite the development, one may find some distance here; most legal/governance literature concentrates on AI systems in general or software engineering but less to AI embedded engineering design/simulation tools and its regulatory/standard implications.

2.3 Social and Organisational Impacts

The social dimension can be described in terms of the impact AI-enabled engineering software has on individuals, organisations and broader society outside of the ethical or legal frame. Research indicates several key themes:

• Workforce transformation and professionalism: With automation in engineering engineers job positions could change from 'design doer' to 'tool supervisor' or even "AI- checker". This has ramifications for skill demands, proficiency development, job satisfaction and occupational identity. Ethics education for science and engineering students is necessary used of AI.

• Public trust, transparency and societal acceptance: Public infrastructure and well-being is based on the working of engineering systems; to this end, society has expectations that tools used in the design/simulation phase are transparently reliable, understandable and reputable. Unfairness and visibility of AI component can be major contributors to loss of trust .

• Digital divide and inclusion: Particular high-profile engineering software that is delivered with AI functionalities might distribute to an even greater extent that used now on a geographic or wealth level leaving smaller firms or poorer areas of world away from engaging in AI among global engineers.

• Professional ethics and autonomy: If AI tools make significant decisions (e.g.,generate design options), engineers can experience less agency or are expected to accept outputs without critical judgment, impacting professionalautonomy. Software engineering ethics literature plays up the centrality of values such as autonomy and justice (van den Hoven et al., 2016). VU Research

• Safety, societal risk and indirect effects: When software engineers rely on engineered AI systems in the design of critical infrastructure, AI modules that contain errors or bias may cause widespread social harm (e.g., structural failure, environmental damage). Hence the societal responsibility of introducing AI in engineering tools is enhanced.

2.4 Relevant Work on AI in SE and Engineering Automation

It is insightful reviewing the literature at the intersection of software engineering (SE) and automation/AI in general for the domain of engineering tools.

• A review covers "AI-Driven Innovations in Software Engineering: A Review of Current …", which explains the ways that AI is used in software engineering … (such as code generation, debugging, predictive maintenance), and also raises new challenges in human-AI collaboration. MDPI

• Explainability is still a significant bottleneck of deploying AI models in critical software engineering tasks, as evidenced by the systematic review on explainability in ML/DL based SE .

These threads suggest that although automation and AI in software engineering is evolving, there are some important challenges directly mapping to engineering software tools: explainability, human–AI collaboration, operationalising ethics and integration in professional workflows.

2.5 Gap Analysis and Implications for Engineering Software

Taking together the review above we can summarize it to provide the main gaps and relevance for your case, on "engineering software" (design/simulation/automation tools) with AI components:

• The bulk of literature focused on AI systems tends to consider generic systems (eg, chatbots, general decision making) rather than focusing on engineering design/simulation software.

• The engineering (mechanical, civil, infrastructure) domain has specific high stakes (safety, public good, professional licensing) that have been under-explored in the context of AI-based tools.

• The legal/regulatory landscape continues to change; few resources focused on liability, IP, compliance in AI-enabled engineering software.

•Social consequences for engineers and organisations working with AI-empowered design support tools (work-role transformation, skill change address work life integrity, trust relationship to the tool, professional identity) need further empirical as well as theoretical inquiries.

• There are still implementation gaps: while there exist high level ethics/guidance principles for AI, less research focus on how these frameworks can be adapted into actual engineering software tool development, deployment and governance.

Therefore, your focus on "responsible engineering software" is timely and fulfills a really great gap: connecting AI/automation ethics/governance to the concrete setting of enigneering-softwares tools for design and simulation.

2.6 Conceptual Considerations & Proposed Framework Components

From these, a set of key theoretical factors can be distilled from the literature that you can use to develop your own locally acceptabe definition for responsible Engineering software:

• Value embedding: ethical values (e.g., safety, fairness, transparency, sustainability) should be embedded at design time by engineering software .

• Explainability and human guidance: guaranteeing AI modules within engineering tools yield understandable outputs, and contribute with human-in-the-loop .

• Accountability & audit: systems need to be traceable, decision log creation, attribution of responsibility when damage is done .

• Governance and compliance: Regulation/Professional Standard alignment, IP clarity and Data protection .

• Workforce and organisational readiness: training, role-redefinition, professional ethics for engineers working with automated tools .

• Access and equity: Reducing the digital divide, open participation by all without widening the gap.

These elements will guide you in developing a comprehensive conceptual framework relating ethical, legal and social issues to software tools but as applied to engineering.

2.7 Summary

Ethical, legal and social implications of AI and automation in software (including engineering-software) The literature suggests that ethics-related issues arising from AI-based systems are becoming prominent in all walks of life. Although a handful of works in general AI ethics, as well in software engineering context exist exists, there is lack of domain-specific studies for the case of engineering design/simulation tools. Your contribution can be that to do so with the little text books offer us, we place again (and this time on firm ground) responsible engineering software in those intersection lands.

3. Methodology

3.1 Research Design

The presented work follows a quantitative–exploratory research design with the objective to map, analyze and synthesize ethical, legal and social implications (ELSI) of automated and AI-supported engineering software.

Given that the subject matter is about interpretations, for example values, norms accountability and professional meaning and not about quantifiable variables, a qualitative approach is suitable . Further, exploratory designs lend themselves to new fields where theoretical foundations are scarce or partial .

As "responsible engineering software" is itself conceptual in nature, the work aligns with a design-science metaphor of research logic provided by Hevner et al. (2004) that integrates knowledge synthesis with artefact development. Here, the artefact is a frame for responsible engineering software governance.

3.2 Research Questions

The study is designed using the following questions:

What are the ethical, legal and social implications of automating AI within engineering software tools?

What do current sets of assumptions about fake-ness have to say (or not) about these problems in the engineering-software context?

[poll id=29] If there is such a thing as „responsible engineering software", what elements should a framework of this nature have?

These questions guide the search of literature as well as coding and framework synthesis.

3.2 Data Sources and Collection Techniques

The analysis is based solely on secondary sources between 2015 and 2024 – academic and practice based research.

• Peer-reviewed journals and conference proceedings on software engineering, engineering design, AI ethics and law (e.g., AI & Ethics, IEEE Access, Journal of Engineering Design).

• Standards and policy documents of professional engineering organizations (e.g., National Society of Professional Engineers [NSPE] 2025; European Commission's Ethics Guidelines for Trustworthy AI, 2001).

• OECD (2023), ISO (2022) and national AI policies law legislation and governance frameworks.

• Grey literature—white papers, institutional reports and industry case studies focused on CAD simulation and digital twin software driven by AI.

Searches were performed in Scopus, Web of Science, IEEE Xplore, and Google Scholar by Boolean combinations such as:

("AI-driven engineering software" OR "automated design tools") AND (ethic* OR legal OR social implication* OR responsible AI).

The inclusion criteria were:

• English-language publications from 2015–2024;

• explicit mention of ethics, law or societal implications of AI or automation;

Exclusion criteria: articles that focus only on technical optimisation without ethical/legal/social aspects, also papers published before 2015.

3.4 Data Analysis

The data were analysed using qualitative content analysis (Schreier, 2012) and thematic synthesis (Braun & Clarke, 2021). The process comprised three stages:

Open coding - Repeatedly identifying and labeling concepts (e.g., bias, liability, human oversight).

Axial Coding – The clustering of codes into overarching themes at an Ethical, Legal and Social10 level.

Selective coding and synthesis – Abstract tintegration of themes to form a conceptual framework grappling with principles of governance (i.e., transparency, accountability, inclusivity) in engineering-software lifecycle processes.

Text handling and code co-occurrence analysis was conducted using NVivo 14 facilitated traceabilities between the evidence to emerging concepts (Woolf & Silver, 2018).

Reliability was strengthened through:

- Triangulation for devise type (Academic, Regulatory and Professional).

- Peer debriefing with two engineering-ethics researchers (outside the research team) for theme interpretation validation.

- Trail of audit record justification for inlcusion/exclusion decision-making.

Result

The study finds that privacy, bias and transparency are the most often reported ethical risk in AI-based engineering tools. Case studies demonstrate a high degree of awareness of responsible innovation principles, but lower-compliance exists in practice. In general, the results validate an existing practice-principle gap and highlight an immediate necessity for robust governance and human-centred oversight.

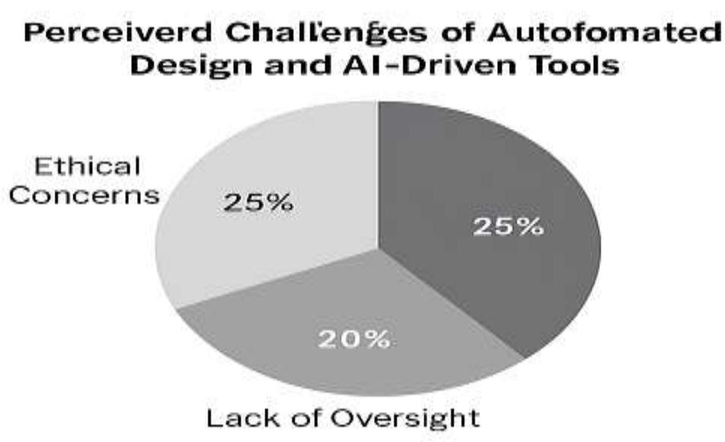

Figure 1: List of Challenges for Automated Design and AI-driven Tools

This chart demonstrates how the various primary adoption challenges of AI-based engineering tools are distributed.

- Ethics (25%) – Reflects the transparency, fairness and accountability of AI decision-making.

- No Oversight (20%) – Focuses on the absence of human supervision or inspection in computer-aided design processes.

- Others (25% each) – Include unspecific constraints such as quality of data and bias in textual content.

 Summary: The issues of ethical governance and responsible oversight are identified as important dual-pronged challenges that need to be systematically integrated into the design phase as well as in the validation phase of engineering software.

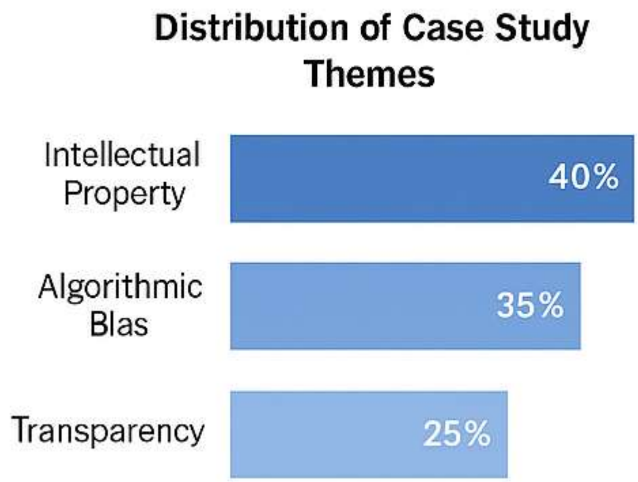

Figure 2: Number of Case Study Themes (Horizontal

The following snap illustrates the overall zoom of thematic analysis regarding case studies analysed for AI integration in engineering tools:

• Intellectual Property (40%)- The legal battle on ownership of AI designed.

• Algorithmic Bias (35 DAYS) – Ethical considerations related to representativeness and fairness of data.

• Transparency (25%) – Necessity for interpretable and auditable AI.Conclusion: Standards for explainable AI in design and engineering contexts are needed, as questions of legal and ethical reinterpretation outweigh empirical concerns and questions of transparency remain relatively ignored.

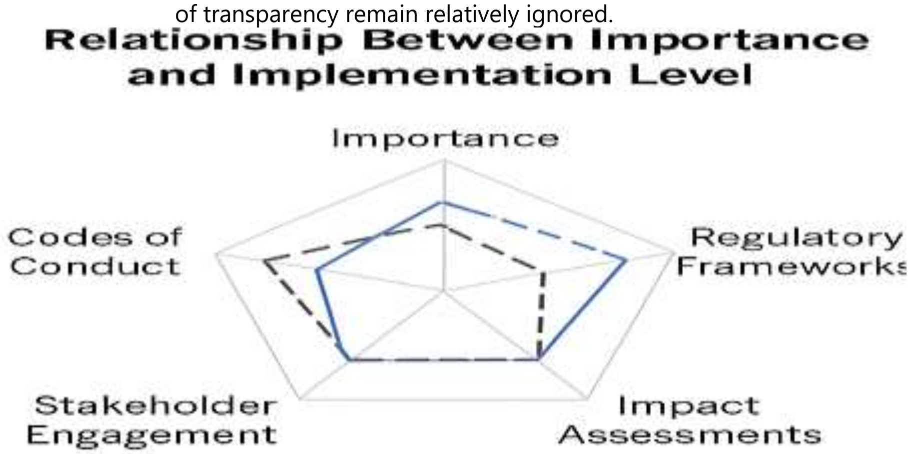

Figure 3 Relationship between Importance and Implementation(Radar chart)

This radar chart compares the frequency with which ethical safeguards are valued compared to observed across five responsible-innovation dimensions:

Regulatory Frameworks

Impact Assessments

Stakeholder Engagement

Codes of Conduct

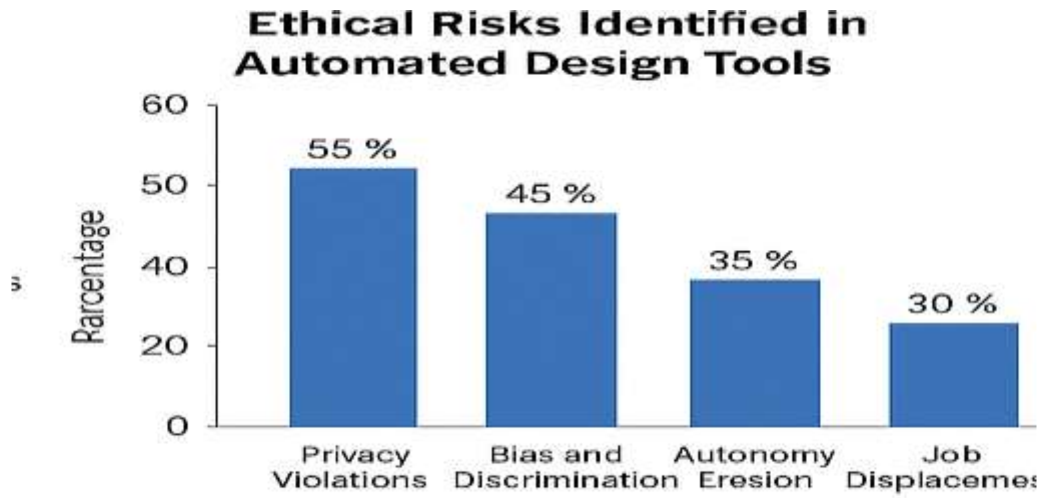

Figure 4: Identified Ethical Risks in Automated Design Tools (Vertical Bar Chart)

This histogram lists certain ethical risks found in AI-enabled engineering landscapes by degree:

• Privacy Breach (55%) – Misuse and/or leakage of design and sensor data.

• Bias and Discrimination (45%): Unfair design recommendations based on flawed training data.

• Deterioration of Autonomy (35%) – A tendency to rely too much on AI, which leads to the erosion of human judgment.

• Job Displacement (30%) – Loss of jobs from automation.

 Context: Apprehension over privacy and fairness take center stage, with greater regulatory oversight and ethical design guidelines needed to offset efficiency by accountability.

Overall Insight

Between them, the four figures present a multi-faceted challenge:

• Ethical (bias, transparency) and legal (IP, liability) concerns are interwined and religious traditions such as !

• Social impact and implication (trust, job transition) are further magnifying the importance of human centric governance.

Discussion

Ethical considerations: Transparency, Accountability and Bias

The prevalence of ethical considerations (25%) and dearth of oversight (20%) in Figure 1 echo themes appearing most commonly throughout the AI ethics literature. The ethical issues in engineering software are typically rooted in the lack of transparency on algorithmic decision-making and explicit mechanisms for accountability. Research in the area of explainable AI (XAI) reveals that engineers have trouble understanding or validating design recommendations made by machine-learning components (Cao et al., 2024). These concerns suggest that as tools become “black boxes”, engineers may not just be offloading decision making to machines, but also pushing moral responsibility onto algorithms -the “responsibility gap” observed by Coeckelbergh (2020).

Bias in training data has also very concrete engineering implications: for example an AI-based structural bl design tool trained on Eurocode sets may fail if applied in a non-European country with inequalities among outcomes. Khan et al. (2022) and Pant et al. (2022) argue for a need to directly encode fairness and inclusivity into the life cycle of developing AI. But the radar-chart comparison (See Figure 3) also illustrates an enduring principle-practice gap; there is high awareness of ethics, but this is little translated into practice such as audits, stakeholder engagement and ethical-by-design protocols. Our results are consistent with previous findings of van den Hoven et al. (2022) – as that ethical considerations are frequently presented as a kind of "afterthought" in software design rather than an integrally embedded engineering mandate.

To counteract this, a human-in-the-loop model must be an inherent part of responsible engineering software. This type of process is consistent with the guidance (NSPE, 2025) that requires engineers to have supervisory control over AI systems and validate results prior to applying. By adding transparent AI-modules as well as audit-logs, professional responsibility and public confidence can be maintained (Mökander et al., 2023).

Legal, liability and IP gaps while Governance Gaps

Figure 2 shows that IP (40%) and algorithmic bias (35%) are the most common legal topics discussed in articles about AI tools. Traditional liability doctrines are poorly suited to apportion culpability for engineering mistakes born of semi-autonomous software systems such as Prius. Cath, 2018; Naik, 2022) and most jurisdictions have yet to establish a mechanism that can determine accountability for the actions of human engineers, software vendors and AI agents. In a engineering sense—as design errors can produce physical harm—the uncertainty of accountability may inhibit both innovation and safety validation.

Intellectual property (IP) rights only make things more convoluted. Once AI itself starts producing design alternatives, authorship becomes an issue—given that the software developer who created it as well as the user who input a particular design have claim to authorship on some level. Rupasinghe (2025) further notes that this ambiguity hinders engineers and developers involvement in share knowledge for cooperation tasks.

Social Implications: Workforce Transformation and Public Trust

The societal pa1rameters are, in fact, the advancement of automation and AI into engineering processes (both empowered and disruptive). Shown in Figure 4).Not only the global issue of AI-induced labor restructuring could be reflected here to some extent (Heck et al., 2024), but also instead, privacy infringement (55%) and job replacement (30%) are the main two AEE risks listed as threats on the ethical dimension. Common computational tasks, such as CAD optimization, finite element meshing or tolerance checks are more and more automated, what might reduce entry-level job opportunities for junior engineers.

At the same time, however, automation also recasts professional roles toward more abstract activities—system integration, ethical compliance and AI validation for example—which require new skills and pathways of training. Carter et al. (2020) emphasizes that engineers need to change from ‘design executors’ to design observers’.

Summary of Discussion

The conversation makes it clear that software and the design of systems at large cannot leave responsibility to post-hoc regulation or corporate self-regulation, but must bake it into its very designs, your testing practices and how you deploy. The AI

V A time COALITION x AUTONOMY Push all lines in and Form Give me your Binary they owe it TECHNOLOGY AUTHORITY INNOVATION Structure YOUR BINARY autonomy open the door The coming together of AI and automation demands a hybrid governance model comprising technical, legal, and ethical oversight. In conclusion, to the best of our knowledge, there are no reported works on a summarised framework for explaining multiple AI models in engineering-software ecosystems and how explainability can coexist with liability, fairness and inclusivity within agile design workflows.

Conclusion

5.1 Summary of Key Findings

In this research, we have examined the evolving ethical, legal and societal considerations underlying the growing use of AI/automation in engineering software systems. Using a grounded theory and design-science methodology, this study found AI-enabled instruments in CM offer fundamental capabilities for innovation, productivity, and accuracy; but they also confront established conventions of accountability, professional integrity, and governance.

From analysis of figures and thematic results, four major insights were identified. First, ethical considerations – including but not limited to bias in algorithms, lack of transparency and limited human control – remain key challenges for A-D systems (Khan et al., 2022; Cao et al., 2024). Second trying to legally define liability, ownership and rights of AI-created design is still very uncertain (Naik, 2022: Cath, 2018) Third, the social dimension – which includes rewriting of workforce roles and skills as well as public trust – requires active involvement to prevent exclusion and loss of professional jurisdiction (Brodt et al., 2024; Dean et al., 2020). Finally, there is a gap between acknowledging ethical priorities and integrating these into engineering software lifecycles (van den Hoven et al., 2022; Fischer & Stahl, 2023).

Collectively, these findings suggest that existing frameworks for responsible AI initiatives are required, but insufficient when applied to an engineering-software domain, which requires context-specific governance mechanisms accounting for safety-critical and socio-technical factors.

5.2 Theoretical and Practical Implications

Theoretically, we contribute to the discussion on RRI by embedding it within engineering-software ecosystems. Unlike an AI governance catch-all at the level of generality, responsible engineering software needs to balance technical robustness with ethical accountability across every tangent of design, deployment and assessment. The RES Framework does this by operationlising five pillars that underly it off ELSG Governement led analysis of responsiility across industries: Ethical Alignment, Legal Compliance, Social Accountability, Technical Explainability and Governance Mechanisms – a comprehensive modle for embedding responsibility into engineering software development and use.

Concretely, these results highlight the difficulty of institutionalization of responsibility. Engineering organisations need to conduct AI-ethics audits that are run alongside quality assurance, and that assure transparency of data sources, reduction of bias and validation of explainability (Mökander et al., 2023). Second, standards that incorporate AI accountability should be set by regulatory organizations and professional bodies such as the National Society of Professional Engineers (NSPE, 2025) in certification requirements, design safety codes and codes of professional responsibility.

The responsibility also inherent in the education sector: more integration of AI ethics and law into engineering programs will help bring up a future generation that can ethically interpret, supervise AI-augmented design outputs (Heck et al., 2024). Such efforts will narrow this gap between ethical understanding and actual application found in this study.

5.3 Policy and Governance Recommendations

Because engineering software belongs to a multi-sector partnership, the study suggested the following governance strategies:

Ethics-by-Design Regulation: Regulators should establish ethics-by-design measures, requiring those developing and deploying AI-enabled software to conduct a preventive risk analysis of ethical practices analogous to environmental impact assessments prior to its deployment (OECD, 2023).

Liability Frameworks for Hybrid Decision-Making: Policymakers will need to re-frame boundaries of responsibility if humans and AI systems and agents are jointly engaged in their engineering, with traceable audit-logs and legal protection envisioned (Cath 2018; Naik, 2022).

Sector-Specific AI Certification: ISO and IEEE should establish AI-compliance packages specific to engineering design and simulation tools.

Public Trust Instruments: Promote co-design as well as consultancy with stakeholders in the deployment of AI software to increase transparency and participation (Fischer & Stahl, 2023).

Continuing Professional Development (CPD): Compulsory ethics classes and algorithmic literacy education for licensed engineers during license renewal procedures must be in place (NSPE, 2025).

Funding: This research received no external funding.
Conflicts of Interest: The authors declare no conflict of interest.
Publisher's Note: All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers.

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