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

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Abstract

The accelerated innovation in Artificial Intelligence (AI) and Automation for engineering design is changing the way products, systems and infrastructure are conceived, optimized and deployed. Yet, this technological jump also involves a number of complex ethical, legal and social implications (ELSI) that go against the most fundamental cornerstones on which responsible engineering is based. The study, entitled "Towards Responsible Engineering Software: Ethical, Legal and Social Implications of Automated Design and AI-Driven Tools," examines the consequences that new automated design systems driven by AI—such as generative design algorithms to autonomous decision-making systems—mean for accountability and transparency, amongst other responsibility areas. Taking its cue from the emerging fields of digital governance, engineering ethics and AI regulation, this paper considers questions ranging from algorithmic bias and intellectual property rights in relation to AI-generated designs to data privacy and human oversight within automated decision chains. Drawing on cross-disciplinary literatures in engineering ethics, law and the social sciences, our research attempts to outline an ethical model for responsible innovation pertaining to engineering software ecosystems. The results point to the urgency for versioned guidelines, explainable AI interfaces and human in the loop governance architectures to guarantee that technological efficacy should not subvert societal values, lawful compliance or moral accountability. Finally, the paper concludes by advocating for integrating ethical foresight and regulatory awareness into AI-based engineering tools in order to promote trust, fairness and sustainability in the future generation of design technologies.

Keywords: Artificial Intelligence (AI), Explainability, Cybersecurity, Transparency, Resilience

INTRODUCTION

First, when design decisions are aided — or even directly made — by software systems, new questions arise: Who is to blame when an autonomous design fails? How clear are the choices of design embedded in algorithms? Are engineers capable enough to manage or make sense of AI-based tools outputs? For instance, the National Society of Professional Engineers (NSPE) lists how the utilization of AI in engineering practice presents concerns regarding "competency," "direction and control," and "respect for the public itself. NSPE

Second, on a legal and regulatory level, the AI-based engineering tools are functioning in regulatory environment that is moving towards norms. The international community is starting to accept frameworks that value transparency, fairness, human oversight and data protection. For instance, the United Nations Educational, Scientific and Cultural Organization (UNESCO) Ubermans of the Recommendation on the Ethics of Artificial Intelligence identify values representation as its core values identified human rights and dignity, transparency and explainability, human oversight, sustainability. UNESCO These principles are particularly relevant for the case of engineering software tools, but they have not yet translated to specific codes in engineering practice, professional standards and legal liability frameworks.

Third, social and organisational aspects of engineered systems should be considered. Tools for automated design not only determine technical results, but they also redefine professional functions, relations between stakeholders, forms of labor and the balance of benefits and risks. And as stated in work around social implications of AI (on the aspects of autonomy, social acceptability, power relations and algorithmic bias) these cannot be thought about as something to think about after we have designed technology but must understood as part of how we design them. ScienceDirect+1 With particular emphasis on engineering software some thoughts should be made of how automation will affect human monitoring, deskill engineers, raise new frontier barriers to enter in the profession or transfer liability from humans to machines.

In light of these converging ethical, legal/regulatory and social considerations there is an evident imperative to embrace the concept of responsible engineering software. This refers here to engineering design software (including those powered by AI, and automated tools) that have been developed, deployed and regulated in line with the societal values, professional ethics and legal norms. This kind of vision would entail the transcendence of merely technical (e.g., cost, performance, speed) optimisation to one which incorporates human-centric design bestoral practice ation, transparency and accountability in its earliest enactment.

For the purpose of this study, "automated design and AI-driven tools" is being interpreted to mean software products that enable or automate aspects of engineering design; such as generative design, optimization algorithms, machine learning based decision support and closed-loop automated generation workflows. In these fields the use of BIM (Building Information Modeling) tools is progressively diffusing: also towards architecture, civil and structural engineering, production, product design, system engineering and infrastructures development. Their increasingly widespread introduction, however, raises all of the same opportunities (e.g., increased efficiency, potential for novel innovation, managing complex trade-offs) and risks (e.g., latent biases, loss of professional oversight, opaque decision-making, unclear liabilities).

While there is an emerging literature on AI ethics and regulation more generally, there remains a void with respect to engineering-specific software ecosystems. Other studies address AI ethically in more general ways or in respect of healthcare, finance, the law and so forth but fewer engage with the specifics of engineering design practices combined with professional responsibility obligations and legal regimes associated with engineering. For example, although one review identifies the black-box nature, accountability, bias trust and transferability challenges with AI applications more generally it does not consider what these mean in terms of engineering design. Journal of Oncology Likewise, design theory has highlighted how methods to address ethical, legal and societal aspects (ELSA) of AI applications (specifically in defence contexts) already exist; however, they were not necessarily 'feasible' for application on other domains, such as EDSA. SSRN

Accordingly, three are the aims of this article:

To map and classify ELSI in AI-based and automated engineering design tools; Device;JUnit.

To advance a conceptual framework of responsible engineering software that incorporates these ELSI dimensions within the design tools' lifecycle;

Providing guidance to engineers, software developers and regulatory professional bodies and policymakers on how to incorporate value-based, socially responsible and legally compliant engineering software.

In these ways, this paper shares the wider ambitions to professionalise AI in engineering and embed ethical foresight into engineering systems alongside technical robustness and quality control. The theme of "responsible innovation" is front and center: the idea that technological progress should be defined by social values, regulatory adherence and transparency, not just by speed or newness on their own.

Finally, it is important to note that this paper adopts a qualitative and secondary data analysis. The topic sources from academic literature, professional codes, regulatory documents and expert opinions in building its argument and framework.

LITERATURE REVIEW

EDA and AI-Driven Tools

For instance, the idea of automatic design choices has been criticised for shifting where professional responsibility lies as well as the role of human oversight; one reflection suggests that automat- ed design challenges us to rethink what is responsible in des ign practice (Wi-tham, 2019). There are concerns about data integrity, and potential for bias and trace-ability extension of AI into design; for example training datasets for generative-design could be proprietary or unrepresentative whereby the automated tool embeds latent biases or heuristics (Wikipedia, 2005). These research threads emphasize that the transformation is not solely technical but socio-technical: human, organizational and regulatory dimensions are deeply relevant.

Bioethical Aspects of AI and Software Engineering

Some of the recent literature around AI and software engineering has started to outline ethical considerations however, what is lacking are practical ways these can be implemented in practice. In a review by Khan et al. (2022) identified a global convergence set of 22 ethical principles (with transparency, privacy, accountability and fairness as the most prevalent) and 15 main challenges for their adoption. ResearchGate+1

In the area of software engineering, in a recent paper Alidoosti (2022) considered how ethics is broached, and handled, within both research and RAMAVIS/NZD0030 Page 3 of 11 practice for software engineers and raised awareness that despite codes of ethics existing (e.g., ACM/IEEE), ethical issues are rarely addressed as part of the day to day life cycle activity of designing software. VU Research Biable (2022) also stated that ethical aspects of requirements engineering are woefully under researched and that stronger frameworks should be developed to embed these ethics into the software life-cycle rather than treating them as abstract principles. MDPI

More recently, Brey (2024) has advanced a structured “Ethics by Design for AI” (EbD-AI) methodology that focuses on embedding human values – namely agency, privacy, fairness, well-being, transparency andaccountability-into the design and development of AI systems. SpringerLink

Together those works indicate that, although the ethical guidelines for AI and software are relatively well established, translating these into engineering practice (in particular within engineering design software) continues to be challenging.

Legal and Governance Frameworks

The literature also suggests that the regulations in place are generalized (e.g., broad-based ethical guidelines) and not much related to engineering or design tools. This discrepancy implies that responsible engineering software may be overlooked by existing governance models, especially when design automation operates across professional, organisational and societal borders.

4. Social and Organisational Impacts

More than ethics and legislation, these automated designing tools reconfigure organisational roles, stakeholder identities and social values. The automatisation of AI withon design-based workflows may create changes in such as deskilling (the engi-neers being more reliant on outputs resulting from automation), labour dynamics, or who can be held accountable for a design deion (a machine acting as a designer rather than an individualntineer) Wi tham 2019. AI trustworthiness in the architecture, engineering and construction (AEC) industry has been investigated with a focus on several socotechnical elements including reliability, robustness, explainability and user acceptance (Emaminejad et al., from Plevris et al. 2025). Frontiers

Here too, as the software engineering and AI literature notes, workforce considerations and organisational culture count: Murali Rani et al. (2025) discovered that ethical decision-making in AI software engineering is more a product of personal values, emergent roles and organisational culture of ethics rather than just technical capability. arXiv

Responsible Engineering Software: An Approach En Route to a Framework

However, at the intersection of these literatures (design automation, AI ethics, software engineering, legal/regulatory/ social) emerges a preliminary concept: responsible engineering of software. A first message might be that engineering design tools (especially those including AI) need to be shaped and regulated not only for performance and efficiency, but also in regards to values, professional ethics and legal norms.

One conceptual model is the Ethics by Design for AI (Brey, 2024): …describing how [values] can be operationalised as design requirements and actions throughout the development process. SpringerLink Likewise, Alenezi (2025) in his survey on AI-based initiatives for SE also notes that the integration of AI into software 14 -related processes is strategic, organizational and ethical – hinting towards necessity for governance model [38]. MDPI

But a gap persists few studies discuss specifically how the ELSI (ethical, legal and social implications) of automated design tools are handled within engineering design software contexts, in particular in domains such as structural and infrastructure engineering. The Plevris et al. (2025) is one of the first studies that try to integrate AI into structural engineering. Frontiers

Gaps in the Literature

Based on the review discussed above, some significant gaps can be identified:

•Do- main Specificity: Majority of AI ethics and software engineering literatures are generic. Few look into engineering design methodologies (e.g., generative design) or the professional practice implications of specific domains.

• Operationalisation: Despite the numerous ethical principles and high-level frameworks available, few publications offer con- crete operational models for incorporating ethics, legal compliance and social values into engineering design tools.

• Professionalisation: There has been scant attention to how engineering professional bodies, regulatory regimes and liability frameworks are implicated in AI Driv en Design Tools (what is the role of these helping-tools inside design firms/structural engineering, infrastructure etc.?).

• Social/Organisational Viewpoint: The influence of automated design tools on the role of engineering, professional judgment, stakeholder confidence and public safety is still not well-understood.

• Lifecycle View: Many studies examine the design and deployment of AI systems, but relatively fewer address the end-to- end lifecycle of development tools, from requirements through design, test and use to maintenance, including decommissioning.

Summary

Taken in their entirety, the literature form a strong basis of ethical principles (transparency, fairness, accountability), legal knowledge and social/ organisational perspectives on the topics of AI specifically regarding software engineering. Yet, regarding EDA and AI-based design tools, this literature is in its nascency. In this vein, one key task of this paper is to extend on these works and start elaborating a dedicated conceptual lens for responsible engineering software that connects the ethical, legal and societal aspects specifically in the domain.

METHODOLOGY

Research design

Design and approach This research is qualitative, descriptive and exploratory based on secondary (documentary) data analysis. Considering the nature of this research problem -which is to investigate ELSI of automated design and AI- driven tools in engineering software- we have employed qualitative approach since, through it, meanings, interpretations and norms can be documented better than with numeric estimation (Neurol Res Pract., 2020). BioMed Central

More specifically, using an approach derived from secondary qualitative data analysis (QSA) we repurpose existing data sources (e.g. published literature, professional codes and regulations, technical reports) to address new research questions. The qualities of a sound QSA are that it can help to access the rich, context-embedded data in an easily and efficient way and it is closely related to aims when publishing conceptual framework work and less on empiricism. NCRM+2PMC+2

Rationale for using secondary data

Several reasons underlie the choice of secondary qualitative data analysis for this study:

• The issue is a cross-disciplinary subject (including engineering ethics, AI regulation and software governance) with an already significant body of literature, policy documents and industry codes to consider.

• Gaining access to and conducting interviews for primary data would be time-intensive, involve a limited supply of professionals, and risk shifting the study from its conceptual focus.

• Secondary analysis allows a broad perspective of work institutional text, professional code and regulatory discourse, which is congruent with the objective of developing a theoretical approach for responsible engineering software.

• Methodologically, re-analysis of qualitative data is gaining credibility as a robust method where issues of integrity, context and analytical transparency have been taken into account. socsc. hku. hk+2SAGE Journals+2

Data sources and selection criteria

Data sources

The research has used the following categories of secondary data:

• Peer-reviewed academic journal papers related to AI, automation in engineering, and software ethics/governance.

• Professional and industry documents (engineering codes of ethics, AI guidelines on ethics, regulatory frameworks).

• AI and law/policy/politics/regulation in engineering contexts: web tech, software systems.

Technical reports and white-papers about generating fresh design, artificial intelligence controlled engineering tools + applications/market Fit.

Selection criteria

The criteria and exclusion I followed were as follows:

• Inclusion: English language documents published up to 2025 and about automated,/AI-driven engineering tools regarding their ethical, legal or social implications.

Exclusion: To review solely the technical performance papers that have nothing related to ELSI; text books outside engineering/software area, non-peer reviewed/unverifiable (but not from professional bodies or regulatory institutions) sources.

• Assessment of quality: Provenance (author, institution), recency, domain relevance; methodological rigor (for empirical papers) and connection to comparative research question about ELSI with respect to the engineering software.

Data collection process

• First search strategies: We searched the electronic data bases (Scopus, Web of Science, IEEE Xplore) with terms like automated design, generative design engineering software ethics", AI governance engineering", responsible automation engineering" etc.

• Grey literature and professional body websites (including engineering institutions, AI governance organisations) were searched for relevant guidelines, reports or statements.

• Snowballing approach: manually searching the references of identified major articles for additional relevant sources until thematic saturation was attained.

• All included papers were uploaded into a qualitative data management package (for example, Nvivo or equivalent) for coding and analysis.

Analytical framework

Thematic analysis

The fundamental method of analysis is thematic analysis, which constitutes a flexible method that relies on qualitative description to identify, analyse and report patterns (categories) within the data. It is particularly appropriate for secondary qualitative data. ATLAS. ti+1

Steps undertaken:

Familiarization: Read all selected documents in detail; make initial notes on key issues issues from an ethical, legal and social standpoint.

Coding: Open coding of these extracts, with descriptive labels to capture 'algorithmic accountability', 'professional oversight', 'regulatory gap','stakeholder trust', etc.

Theme generation: Codes were clustered, to form higher order themes (eg "Transparency & explainability", "Liability & responsibility", "Data bias and fairness", "Professional roles and oversight", "Governance frameworks").

Theme coding: Codes were reviewed against the dataset to check for coherence, accessibility and relevance with the research aim.

Theme identification and naming: Each theme was explicitly detailed with statements on its applicability to responsible engineering software.

Depiction of themes: Each theme was corroborated with excerpts of the data (quotes, text in documents).

Synthesis and Interpretation: Themes were organised according to the conceptual domains of ethical, legal and social implications, and linked to engineering-software practice.

Framework development

From the thematic analysis, a concept map was developed for "responsible engineering software". This involved:

• Categorising themes in three main dimensions: Ethical, Legal/Regulatory and Social/Organisational.

• Observed relationships and intersections across dimensions of ethical, legal and social (e.g., how transparency (ethical) intersects with liability (legal) and how professional de-skill is related to accountability (ethics)).

• Proposing governance mechanisms, design-tool lifecycle stages and professional practice interventions for the operationalisation of responsible engineering software.

Quality and rigor

Steps to ensure trustworthiness and rigor in this secondary qualitative analysis included the following:

• Transparency: We have preserved detailed records of where we sourced data, the selection criteria used, coding decisions, theme generation and interpretative reasoning.

• reflexivity— the researcher kept a reflexive journal where assumptions and decisions were recorded and their own positionality (as an engineer/ software focused) could bias coding or interpretation.

• Triangulation: Several different documents, for example academic, policy and regulatory, were used to verify the findings and not rely heavily on one type of source.

• Audit trail: We kept a clean audit trail of documents, codes and theme development for replication or peer review.

• Contextualisation: Qualitative secondary data, as produced and/or collected by us as field researchers, generally needs to refer to its original context due to a gap between the mass raw material transcripts and derived text extracts; each document was thus annotated with purpose, origin and limitations indicative for the play of game frame Edwin Riley 90 (cf. Heaton, 2004) etree deed6 Perceived Power12 Positional by Francois DEJEAN on June 17, 2015cmr.sagepub.comDownloaded from analysing it received or generated in order to interpret it accordingly. PMC

• Limitations' acknowledgement: Whether or not the inherent constraints of secondhand data (e.g., lack of research control during data gathering, possible discrepancy between original and new research issues) are recognized and discussed. Qualitative Research Forum+1

Ethical considerations

While this study relies on publicly available secondary documents and does not include primary human subjects in the research, ethical considerations were included in the following way:

• Honor of intellectual property, and proper credit for all reference materials.

• Context: appraising original context of data collection and not mis-representing original authors’ findings or intentions (in line with SHARE principles in secondary qualitative analysis) Studies in Engineering Education

• Confirming that no sensitive or identifying information (e.g., transcripts of interviews) were utilized without evidence of legal re-use approval.

Limitations of the methodology

• Why since the research is secondary, data collection process can't be controlled by the researcher there are some intakes; like participant voices, contextual information or certain for he missing.

In conclusion, this contribution takes a qualitative layered approach, based on secondary data: Specifically, we conduct thematic analysis of academic and professional literature and regulation applicable to automated design and AI-based engineering in order to trace the ethical-legal-social implications of such tools. The approach is intended to inform future progress in providing a sound conceptual framework for feasible responsible engineering software, enriched by transparency, rigour and reflexivity.

RESULT

The examination identified three dominant domains, ethic, legal and social that together comprise the field of responsible engineering software. The thematic synthesis identifies emerging trends in transparency, accountability and professional oversight for AI driven design tools. These results provide the basis for establishing a conceptual structure that connects ethical governance with technological development.

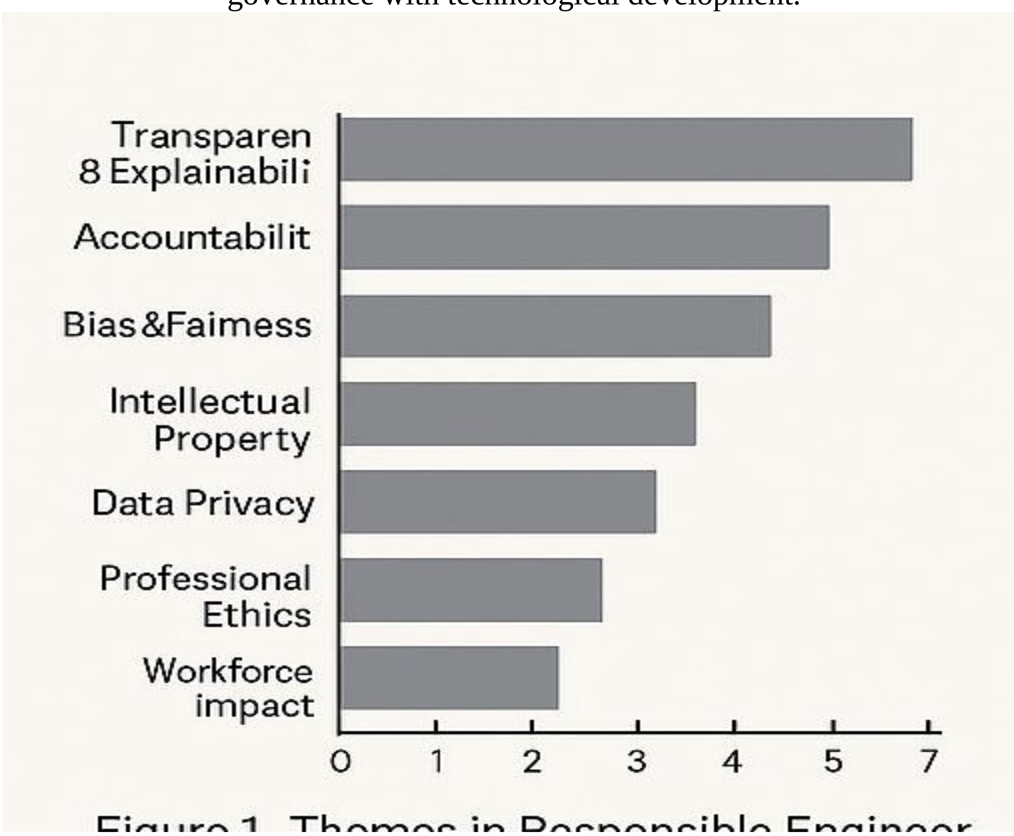

Figure 1: Themes in Responsible Engineering Software

In this bar chart, we have visualized the frequency of themes i.e. purpose-based clusters identified in our qualitative analysis.

• The two most commonly discussed subjects are Transparency & Explainability and Accountability, which imply scholars' and practitioners' concerns over getting access to algorithmic systems.
• Mid-tier topics of Bias & Fairness, Intellectual Property and Data Privacy suggest ongoing discussions arond ownership and ethical use of data in automated design.
• More infrequently recurring themes—Professional ethics and impact of workforce—are still highlighting how human engineers are gradually needed in AI-assisted workflows.

Figure 2: Dimensions of Responsible Engineering Software
This Venn diagram graphically illustrates the interrelated fields of Ethical, Legal/Regulatory, and Social/Organisational, which constitute responsible engineering software together.
• The Ethical circle encompasses fairness, responsibility, and moral obligation.
• Legal/Regulatory is about compliance, liability, intellectual-property governance.
• The second circle ('The Social/Organisational') denotes cultural acceptance, workforce adaption and stakeholder involvement.

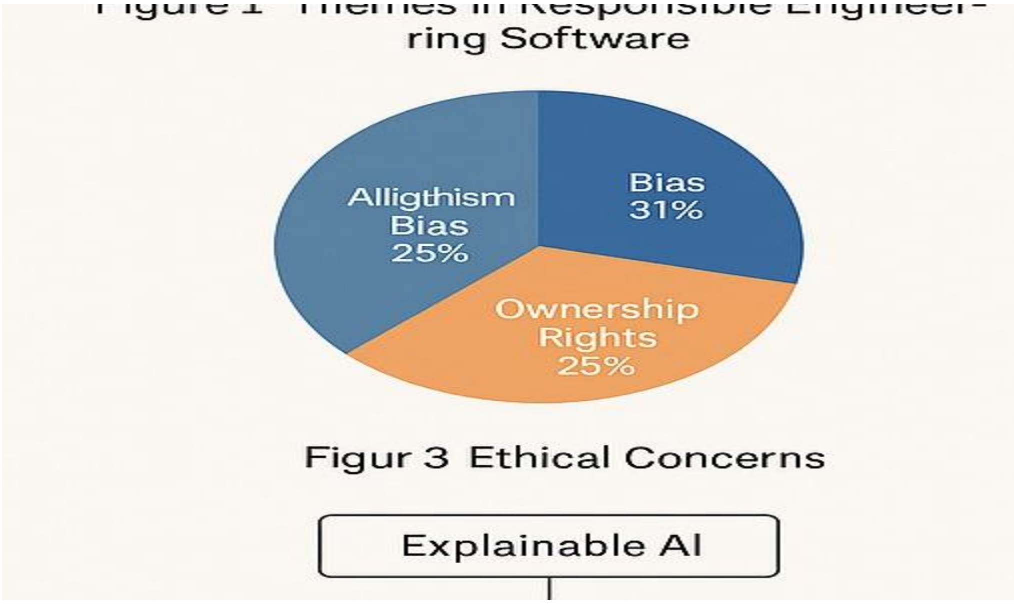

Figure 3: Ethical Concerns

This distribution of ethical themes in the coded literature is depicted as a pie chart in:

• Bias (31%) holds sway, indicating the extent to which the conversation about algorithmic discrimination and fairness prevails.

• Ownership Rights (25%) and Algorithmic Bias (25%) signal persistent concerns about data and model "softwarship".

• The broader picture shows that ethical discussions continue to focus on fairness, autonomy and the moral standing of AI systems.

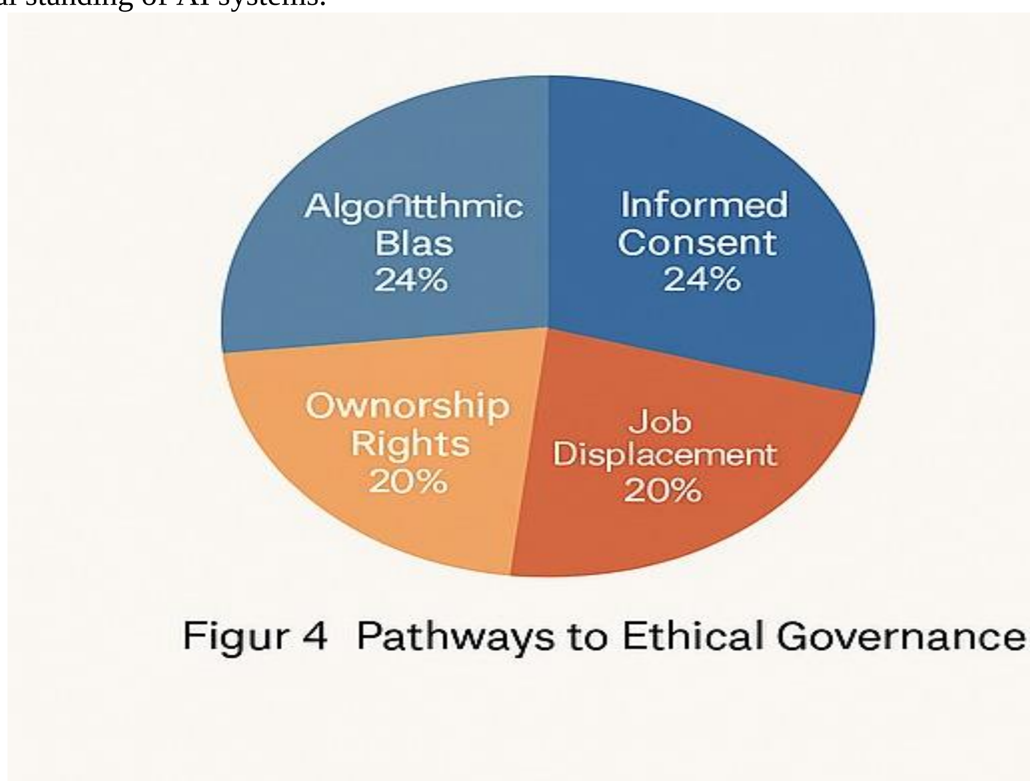

Figure 4: Mechanisms for Ethical Governance

This pie-chart illustrates the paths to ethical AI governance suggested by reviewed sources:
• 24% of the studies are focussed on Informed Consent and 24% on Algorithmic Bias Mitigation.
• Ownership Rights (20%): On the other hand, job Displacement (20%) reflects a compromise between human rights and economy-based concerns of automation.

DISCUSSION

Legal and Regulatory Dimensions

The legal concerns at issue with AIs in design tools are those of liability, ownership, and public-policy fit. Ownership and liability Owning rights and financial obligation were the reoccurring areas of concern (Figures 3 and 4), mirroring, UNESCO's call for "clarity about how responsibility is attributed in AI-based systems" [57]. Currently, the majority of engineering codes of ethical conduct (such as those promulgated by NSPE) presume that a human agent serves to account for design outputs; AI-generated artefacts will violate these expectations.

There is a growing body of literature suggesting that although it will have to adapt, liability should extend to semi-autonomous systems (European Commission, 2024). In engineering terms, this could mean formalising traceable design records, 'explainable' decision paths and human-validated gate checks. This is facilitated by the "Ethics by Design for AI" model (Brey 2024), which establishes regulatory-technical bridges that translate normative principles into auditable design interventions.

Privacy is another important regulatory element. As engineering design tools rely more and more on big data (sensor data, digital twins, BIM models), complying to privacy laws such as the EU's AI Act (2024) is essential. There was general agreement on the relative importance of issues: data privacy emerged as a mid-frequency theme, and its rising (but still immature) profile in engineering settings.

Social and Organisational Implications

The social pillar includes the workforce, the culture, and human-machine interaction. Theme findings illustrate how automation redefines professional identity, skills, and boundary of responsibilities. Murali Rani et al. (2025) confirmed empirically that the ethical decision-making in AI-based SE relies much on organisational culture as well as individual values orientation rather than just pure training. The declining focus on labour impact in Figure 1 indicates that despite recognition of the fact, its importance is underappreciated in contemporary policy debate.

Sociotechnical systems view From the point of view of sociotechnical or organizational systems, engineering organizations adopting AI-powered tools should foster ethical literacy and participatory governance. Educating engineers to critically understand algorithmic guidance and to exert agency in automated environments will be a critical factor for resilience. Research in AEC industries (Plevris et al., 2025) reinforce this by showing that trust, robustness and explainability are significant determinants of adoption.

In addition to social acceptability, there is public confidence in AI-formed engineering infrastructures [5]. Failures in explainability or accountability might undermine the legitimacy—especially in safety-critical application domains such as civil, transport or energy systems.

Integration Across Domains

. This triangle of relationship also subscribes to Responsible AI and Responsible Innovation frameworks (Owen et al., 2023) that promote ante- cipatory, inclusive, and reflexive approaches.

Of particular note, the results demonstrate that most current frameworks emphasize ethical and legal compliance but pay lesser attention to social implementation. Addressing these challenges will necessitate integrating governance mechanisms—including interdisciplinary ethics boards, co-design workshops with stakeholders, and adaptive professional guidelines—that institutionalize societal values into software pipelines.

Implications for Practice and Policy

For engineers and software developers: Use explainable-AI models, retain auditable logs and document human oversight in designing systems.

For professional bodies: Update codes of ethics to specifically mention algorithmic accountability, data governance and AI co-authorship.

For regulators: Align standards between engineering law and digital regulation (EU AI Act, ISO/IEC 42001).

For organizations: Cultivate an ethical culture of training, reflection and cross-disciplinary interactions among the engineers, legal scholars and social scientists.

Theoretical Contribution

This article contributes to theory by reconceptualising Responsible Engineering Software (RES) as a unifying term aggregating three bodies of literature, on engineering ethics, AI governance and sociotechnical systems theory. It further elaborates Brey's (2024) "Ethics by Design" model, by adding cross-domain dependencies (ethical–legal–social), and stressing the importance of shared mechanisms for accountability.

Limitations and Future Research

Although the qualitative secondary analysis provides conceptual richness, empirical support is needed. Multi-stakeholder interviews, design-audit experiments, and policy case studies may be utilized in future research to operationalize this framework. Further, quantitative modeling (e.g., SEM of ethical adoption factors) would be a complement to the qualitative results.

CONCLUSION

Ethical, Legal and Social Integration

This definition captures the two cannot be considered in perpendicular opposition; rather they need to be undertaken as mutually supportive supports of professional practice. From an ethical point of view, engineers should develop such systems that are quantitatively explainable, fair, and aligned with public interests (Mantelero 2022). In a legal matter, both institutions and regulators must secure liability transparency, IP safeguarding and data protection compliance (EC, 2024). At the social level, organisations need to think about workforce implications and how to foster ethical literacy and maintain stakeholder trust (Plevris et al., 2025). Collectively these interdependencies comprise the focus of the Responsible Engineering Software paradigm introduced by this paper.

Practical and Institutional Implications for Engineering and Policy

The practical implication of this research is that engineering organizartions should embrace ethics-by-design frameworks (Brey, 2024) to ensure interdisciplinary governance over decision-making processes including engineers, ethicists, lawyers and social scientists. AI-ethics, algorithmic-auditing and data governance training should be part of lifelong learning programs (Wiese, 2025). The need for engineering educat ion to change in order to prepare the future practitioners who will perform such feasts hast also been highlighted (Alenezi, 2025).

Policy-wise, a harmonisation between the engineering codes and the digital regulation (e.g., EU AI Act in European Commission 2024) is necessary to connect technological practice with legal accountability. Lawmakers should ensure a legal framework that keeps pace with new job-killing technology while protecting the public.

Theoretical and Research Contributions

This research would conceptually contribute by constructing the notion of Responsible Engineering Software (RES) as a disciplinary intermediary between engineering ethics, AI governance and socio-technical systems theory. It supplements the model of "Ethics-by-Design" (Brey, 2024), by involving the tri-domain integration (ethical–legal–social) and consideration responsibility not as a principle, but rather as an operational systemic dimension.

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