

Engineering Leadership in the Era of Digital Transformation: A Review of Values, Integrity, and Responsible Innovation

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Abstract

The rapid advancement of digital technologies, artificial intelligence (AI), automation, and the Fourth Industrial Revolution (Industry 4.0) has transformed the role of engineers from technical specialists to strategic leaders within organizations. The success of technological development depends not only on technical expertise but also on the values, ethics, and integrity demonstrated by leaders. This article aims to examine the importance of values-based leadership among engineers in addressing the challenges of digital transformation. A qualitative conceptual review approach was employed through an analysis of literature on leadership theory, professional ethics, AI ethics, and responsible innovation. The findings indicate that trustworthiness, integrity, accountability, fairness, and social responsibility are critical elements contributing to effective engineering leadership. Furthermore, challenges such as ethical dilemmas associated with artificial intelligence, organizational pressures, data security and privacy concerns, and technological sustainability require engineering leaders to make decisions grounded in strong moral principles and supported by enabling organizational conditions. This study proposes a Values-Based Engineering Leadership Model as a framework for higher education institutions, industrial organizations, professional bodies, and policymakers. The article contributes to the growing body of knowledge on technical leadership and reinforces the role of engineers as ethical and sustainable agents of technological development.

Keywords: Engineering Leadership, Integrity, Values, Digital Transformation, Technology Ethics, Responsible Innovation

Introduction

Digital transformation in the twenty-first century has fundamentally reshaped the landscape of technological development and organizational management. Vial (2019) conceptualizes

digital transformation as a process in which digital technologies disrupt organizations and trigger strategic responses that alter how value is created. The emergence of technologies such as artificial intelligence (AI), the Internet of Things (IoT), big data analytics, and automation, which Schwab (2017) places at the core of the Fourth Industrial Revolution and which Xu et al. (2018) review under the label Industry 4.0, has increased organizational reliance on engineering expertise. Brynjolfsson and McAfee (2014) similarly argue that digital technologies are extending automation from physical to cognitive tasks, thereby changing the nature of work and the distribution of its benefits. In this context, engineers are no longer viewed solely as technical practitioners but also as leaders who influence organizational direction and technological advancement.

However, the growing influence of technology has also introduced numerous ethical challenges. Issues related to data privacy, cybersecurity, algorithmic bias, environmental sustainability, and social responsibility require engineers to make decisions that are not only technically sound but also ethically grounded. Jobin et al. (2019) reviewed 84 AI ethics guideline documents and found an emerging convergence around five principles (transparency, justice and fairness, non-maleficence, responsibility, and privacy), although the interpretation and implementation of these principles differ considerably. Mittelstadt et al. (2016) similarly map ethical concerns raised by algorithms, including inscrutable evidence, unfair outcomes, and difficulties in tracing responsibility, while Zuboff (2019) shows how large-scale data extraction can erode privacy and autonomy. Failures of engineering judgment can also be catastrophic, as the analysis of the Boeing 737 MAX accidents by Herkert et al. (2020) illustrates. Consequently, values-based engineering leadership has become increasingly important in ensuring that technological development benefits society as a whole.

The issue is also of national relevance. Malaysia's National Fourth Industrial Revolution (4IR) Policy aims to drive socio-economic transformation through the ethical use of 4IR technologies and adopts a humanity-centred approach (Economic Planning Unit, 2021). Realizing this ambition depends heavily on the engineers who design, deploy, and govern digital systems, and on the quality of their leadership.

Despite extensive scholarship on leadership theory (Northouse, 2021; Yukl & Gardner, 2020), engineering ethics (Davis, 1998; Harris et al., 2019), and AI ethics (Floridi et al., 2018; Jobin et al., 2019), these literatures are often developed in parallel. Leadership research tends to be generic across professions, engineering ethics frequently focuses on individual compliance with professional codes, and AI ethics often emphasizes principles rather than the leaders who must operationalize them (Hagendorff, 2020). Relatively little work integrates these strands to explain what kind of leadership engineers need in the digital era. This article addresses that gap.

This article aims to examine the role of engineering leadership in the era of digital transformation and identify the key values necessary for fostering ethical and sustainable leadership practices. Specifically, it addresses three questions: (1) which values underpin effective engineering leadership in the digital era; (2) which challenges test those values; and (3) how these values can be integrated into a framework that guides education, industry practice, and policy. The remainder of the article reviews the relevant literature, explains the

methodology, presents the findings and the proposed model, and concludes with implications and recommendations.

Literature Review

The Concept of Engineering Leadership

Engineering leadership refers to the ability of individuals with engineering backgrounds to influence, guide, and manage people and organizations toward the achievement of specific goals. This view builds on the general understanding of leadership as a process of influencing others to understand and agree about what needs to be done and how to do it, and of facilitating individual and collective efforts to accomplish shared objectives (Yukl & Gardner, 2020). Rottmann et al. (2015) examined how engineers in four Canadian engineering-intensive firms understand leadership, using nine focus groups and seven interviews. They found that engineers tend to resist leadership paradigms imported from other disciplines, yet lead in ways that blend their professional identities with recognized forms of influence. Their compound model describes three leadership orientations (technical mastery, collaborative optimization, and organizational innovation), which together reflect a combination of technical competence, interpersonal skills, and strategic thinking.

Traditional leadership models that emphasize authority and control are becoming less relevant in dynamic technological environments. Instead, organizations increasingly require leaders who can promote innovation, collaboration, and continuous learning. Transformational leadership, which Bass and Riggio (2006) characterize through idealized influence, inspirational motivation, intellectual stimulation, and individualized consideration, is often regarded as better suited to such settings because it focuses on developing followers and mobilizing them around a shared vision.

The engineering education literature points in the same direction. Farr and Brazil (2009) argue that engineers who move into management roles need deliberate leadership skills development, and Kumar and Hsiao (2007) contend that leadership and other so-called soft skills should be cultivated within engineering classes rather than learned only through experience. Shuman et al. (2005) examined whether professional skills such as ethical responsibility, teamwork, and communication, which accreditation criteria require, can be taught and assessed, and Passow and Passow (2017) synthesized the literature on the competencies that undergraduate engineering programs should emphasize. Together, these studies suggest that technical excellence is necessary but insufficient for those who lead engineering work.

Values-Based Leadership

Values-based leadership emphasizes the role of moral values in decision-making and organizational management. Northouse (2021) argues that ethical leadership rests on principles such as respect for others, service, justice, honesty, and community building, which translate into honesty, fairness, and concern for others' welfare in everyday decisions. Ciulla (2014) and her contributors similarly maintain that ethics is not an add-on to leadership but an integral part of what it means to lead well.

Empirical research has operationalized these ideas in several ways. Brown and Treviño (2006) reviewed the literature on ethical leadership and its antecedents and outcomes, building on

the social learning perspective developed by Brown et al. (2005), in which leaders influence followers by modelling appropriate conduct and by communicating about, rewarding, and enforcing ethical standards. Treviño et al. (2000) offer a complementary view in which leaders earn a reputation for ethical leadership by being both a moral person (displaying integrity, honesty, and concern for people) and a moral manager (actively role-modelling, communicating about values, and using rewards and discipline to reinforce them). Related perspectives include authentic leadership, which stresses self-awareness and consistency between internalized values and action (Avolio & Gardner, 2005), and servant leadership, which places the needs of others ahead of the leader's own (Greenleaf, 1977). Maak and Pless (2006) extend the discussion to responsible leadership, which they describe as a relational and ethical phenomenon in which leaders interact with a wide range of stakeholders inside and outside the organization.

Within the engineering profession, these values are particularly important because technical decisions often have direct implications for human safety, societal well-being, and environmental sustainability. Professional codes make this explicit: the National Society of Professional Engineers (NSPE, 2019) requires engineers to hold paramount the safety, health, and welfare of the public, and the Institution of Engineering and Technology (IET, 2024) expects members to safeguard the public interest in matters of health, safety, and the environment while balancing the often conflicting interests of employers, society, and the environment. Therefore, engineers must balance organizational objectives with their professional and social responsibilities (Harris et al., 2019).

Integrity in the Engineering Profession

Integrity serves as the foundation of engineering professionalism. Davis (1998) conceives a profession as a group of practitioners who voluntarily commit to shared standards of conduct that go beyond what law and ordinary morality require, and codes of ethics are the visible expression of those standards. Codes established by professional bodies such as the IET (2024), the NSPE (2019), and the Institute of Electrical and Electronics Engineers (IEEE, 2020) emphasize trustworthiness, transparency, and accountability, together with honesty in public statements, avoidance of conflicts of interest, and prompt disclosure of risks to the public. In Malaysia, the Registration of Engineers Act 1967 (Act 138) provides the statutory basis for registering engineers and establishes the Board of Engineers Malaysia, thereby linking professional standing to enforceable standards of conduct (Government of Malaysia, 1967).

Previous studies have shown that failures in maintaining integrity can result in significant organizational and societal consequences. Vaughan's (1996) sociological analysis of the 1986 Challenger launch decision attributes the disaster not to isolated amoral calculation but to the gradual normalization of deviance within an organizational culture that came to accept known technical anomalies as routine. More recently, Herkert et al. (2020) identify design flaws in the flight-control software of the Boeing 737 MAX, internal pressure to keep pace with a competitor, limited transparency about the new software, and weak regulatory oversight among the factors behind two fatal accidents. They conclude that the voice of engineers within large organizations needs to be strengthened and that engineering ethics education should give greater attention to moral courage.

Meta-analytic evidence indicates that unethical decisions at work arise from the interaction of individual characteristics, the nature of the moral issue, and the organizational environment (Kish-Gephart et al., 2010). The ethical climate of an organization, meaning shared perceptions about what constitutes ethically correct behavior and how ethical issues should be handled, is one such environmental factor (Victor & Cullen, 1988). Leaders shape that climate and also whether employees feel safe enough to raise concerns: psychological safety supports learning and speaking up in teams (Edmondson, 1999), and leader openness is associated with employee voice (Detert & Burris, 2007). Therefore, fostering a culture of integrity should be a priority in engineering education and professional development, and not merely a matter of individual compliance.

Challenges of Engineering Leadership in the Digital Era

Digital technological advancements have created a range of new leadership challenges. These include technology risk management, information security, AI-related ethical dilemmas, and the demand for continuous innovation. According to Schwab (2017), the Fourth Industrial Revolution requires leaders who can balance technological progress with human well-being. Five clusters of challenges recur in the literature and are discussed below.

AI ethics and accountability

The proliferation of AI ethics principles has not by itself resolved how engineering leaders should act. Floridi et al. (2018) propose five principles for a good AI society: beneficence, non-maleficence, autonomy, justice, and explicability. Jobin et al. (2019) observe that although guidelines converge around a small set of principles, they diverge substantially in how those principles are interpreted and implemented. Hagendorff (2020) argues that many guidelines lack enforcement mechanisms and that aspects which are difficult to operationalize receive less attention. Dignum (2019) responds by framing responsible AI around accountability, responsibility, and transparency, emphasizing that these are properties of the sociotechnical system and of the people who govern it, and not only of algorithms. Raji et al. (2020) similarly argue that an accountability gap arises when organizations lack internal processes to audit AI systems across their development lifecycle, and they propose an end-to-end auditing framework. These contributions indicate that engineering leaders are the actors who must translate principles into organizational routines.

Algorithmic bias and fairness

Algorithmic systems can reproduce or amplify social inequities. Mittelstadt et al. (2016) identify unfair outcomes and inscrutable evidence among the central ethical concerns about algorithms. Obermeyer et al. (2019) showed that a widely used health-risk algorithm assigned the same risk scores to Black patients who were considerably sicker than White patients, because it used health care costs as a proxy for health needs. Buolamwini and Gebre (2018) found that commercial gender-classification systems performed markedly worse for darker-skinned women than for lighter-skinned men. Mehrabi et al. (2021) survey sources of bias in data, algorithms, and user interaction, together with the fairness definitions proposed to address them. Such cases show that fairness failures often originate in seemingly neutral engineering choices, such as the selection of a target variable or a training data set, which leaders are responsible for scrutinizing.

Data privacy, security, and regulation

Data-driven business models intensify privacy and security concerns. Zuboff (2019) describes surveillance capitalism as an economic logic that extracts behavioral data at scale, raising questions about autonomy and consent. Regulation is tightening in response. In Malaysia, the Personal Data Protection Act 2010 (Act 709) was amended by the Personal Data Protection (Amendment) Act 2024 (Act A1727), whose phased commencement in 2025 introduced, among other changes, the mandatory appointment of data protection officers and mandatory notification of personal data breaches for data controllers (Government of Malaysia, 2010, 2024). In the European Union, Regulation (EU) 2024/1689 adopts a risk-based approach to AI that imposes obligations in proportion to the risk a system poses (European Union, 2024). Compliance, however, sets only a minimum. Engineers who design systems may recognize risks before regulators do, and their willingness to disclose and mitigate those risks depends on professional integrity and organizational support.

Sustainability and societal impact

Digital innovation must also be reconciled with sustainable development. The Brundtland Commission defined sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet their own (World Commission on Environment and Development, 1987). The 2030 Agenda adopted by the United Nations (2015) translates this idea into seventeen Sustainable Development Goals, including goals on industry, innovation, and infrastructure and on responsible consumption and production. For engineering leaders, technological sustainability therefore entails assessing environmental and social consequences across the life cycle of systems rather than optimizing short-term performance alone.

Organizational pressures, diversity, and global competition

Engineering leaders must also manage workforce diversity, organizational cultural changes, and increasing global competition. Competitive and schedule pressure can erode ethical decision-making, as the Challenger and 737 MAX cases suggest (Herkert et al., 2020; Vaughan, 1996). At the same time, diverse workforces require inclusive leadership: Shore et al. (2011) define inclusion in terms of employees' simultaneous needs for belongingness and uniqueness and review how work-group practices can satisfy both. These circumstances further highlight the importance of values-based leadership as a guide for navigating complex decision-making environments.

Responsible Innovation

A related body of work offers a process-oriented lens. Stilgoe et al. (2013) propose a framework for responsible innovation built on four dimensions: anticipation of possible impacts, reflexivity about assumptions and purposes, inclusion of a broader range of stakeholders in deliberation, and responsiveness to emerging knowledge and public concerns. Von Schomberg (2013) describes responsible research and innovation as a transparent, interactive process in which societal actors and innovators become mutually responsive with a view to the ethical acceptability, sustainability, and societal desirability of innovation. These dimensions complement the stakeholder orientation of responsible leadership (Maak & Pless, 2006) and offer engineering leaders concrete practices through which values can be expressed in project governance.

Malaysian and Islamic Ethical Perspectives

Because engineering leaders operate within cultural and institutional contexts, Malaysian and Islamic ethical perspectives deserve attention as one of several relevant lenses. Malaysia's National Integrity Plan was introduced to strengthen ethical values and integrity across society (Malaysian Integrity Institute, 2004), and the National 4IR Policy explicitly links technological transformation to ethical use and a humanity-centred approach (Economic Planning Unit, 2021). Within Islamic ethical thought, which is one influential source of moral reference in Malaysia's multicultural society, leadership is often discussed in terms of trust, justice, and accountability, although interpretations vary across schools of thought and contexts. Beekun and Badawi (2005) examine an Islamic perspective on balancing ethical responsibility among multiple organizational stakeholders, an orientation that resonates with stakeholder-based views of responsible leadership. Ali and Al-Owaihian (2008) review the Islamic work ethic and its emphasis on cooperation, dedication to work, and fairness in dealings. The concept of *amanah*, understood as trust or stewardship, can thus be read as aligned with the notions of trustworthiness and accountability that appear in international engineering codes. Nevertheless, the empirical relationship between such values and engineering leadership outcomes remains underexplored, and the present article treats Malaysian and Islamic ethical perspectives as a complementary source of meaning, not as a representation of Malaysian culture or Islamic ethics as a whole, and not as a separate model.

Methodology

This study adopts a qualitative conceptual review approach. Conceptual articles aim to build theoretical understanding by synthesizing existing knowledge and proposing relationships among constructs, rather than by testing hypotheses with new data (Jaakkola, 2020), and integrative literature review is an established method for synthesizing perspectives across fragmented bodies of research (Snyder, 2019). Data were collected through document analysis (Bowen, 2009) and a comprehensive review of academic journal articles, scholarly books, professional reports, codes of ethics, and policy documents related to leadership, ethics, and engineering.

The analysis was conducted in three stages, following guidance for structured and concept-centric literature reviews (Webster & Watson, 2002). First, relevant sources on engineering leadership and professional ethics were identified and collected. Second, major themes were categorized based on values, integrity, and digital transformation concepts, drawing on the logic of thematic analysis (Braun & Clarke, 2006) to move from recurring descriptions to named themes. Third, the literature was synthesized to develop a conceptual framework for values-based engineering leadership.

This approach is appropriate because it enables researchers to develop a comprehensive understanding of the relationship between leadership, technology, and values within the context of modern organizational development. Sources were prioritized when they were peer-reviewed, issued by recognized professional or governmental bodies, or widely cited foundational texts. As with any conceptual review, the findings reflect the sources that were selected and the interpretive judgments of the authors; they should therefore be read as a theoretically grounded proposal that requires empirical validation.

Findings and Discussion

The literature review identified five key elements that form the foundation of values-based engineering leadership: trustworthiness, integrity, accountability, fairness, and social responsibility. Table 1 summarizes each element and its expression in digital-era engineering practice, and the subsections below discuss them in turn.

Table 1

Core Values of Values-Based Engineering Leadership in the Digital Era

Core value	Leadership meaning	Digital-era engineering expression	Key sources
Trustworthiness	Competence, benevolence, and integrity that stakeholders can rely on	Safe and explicable systems; honest communication of limits and risks	Mayer et al. (1995); Dirks & Ferrin (2002); Floridi et al. (2018)
Integrity	Consistency between values, principles, and actions	Resisting schedule and cost pressure; avoiding conflicts of interest	Treviño et al. (2000); Avolio & Gardner (2005); NSPE (2019)
Accountability	Answerability for decisions and outcomes	Clear ownership of risk decisions; algorithmic auditing and traceability	Dignum (2019); Raji et al. (2020); Mittelstadt et al. (2016)
Fairness	Just, transparent, and inclusive decision-making	Bias testing across groups; inclusive teams and processes	Obermeyer et al. (2019); Mehrabi et al. (2021); Shore et al. (2011)
Social responsibility	Concern for stakeholders, society, and the environment	Anticipating societal impacts; sustainability across the life cycle	Maak & Pless (2006); Stilgoe et al. (2013); United Nations (2015)

Trustworthiness

Trustworthiness refers to a leader's ability to fulfill responsibilities honestly and professionally. Mayer et al. (1995) conceptualize the trustworthiness of a trustee in terms of ability, benevolence, and integrity, which fits the dual demands on engineering leaders: demonstrable competence and sincere concern for the interests of those affected by their decisions. Meta-analytic evidence shows that trust in leadership is positively associated with outcomes such as job performance, organizational citizenship behavior, and commitment, and negatively associated with turnover intentions (Dirks & Ferrin, 2002). In engineering, trustworthiness is essential to ensuring that the safety of products, systems, and users remains a top priority. In digital settings, it extends to the systems themselves: explicability, understood as intelligibility and accountability, is among the principles proposed for a good AI society (Floridi et al., 2018), and transparency is the most frequently cited principle in AI ethics guidelines (Jobin et al., 2019). Leaders who create conditions in which team members feel safe to share concerns also strengthen trust (Edmondson, 1999; Sinek, 2014).

Integrity

Integrity involves consistency between values, principles, and actions. Treviño et al. (2000) place integrity, honesty, and trustworthiness at the center of the moral person dimension of ethical leadership, and Avolio and Gardner (2005) similarly link authentic leadership to alignment between a leader's internalized values and behavior. Leaders who demonstrate integrity tend to gain greater trust from employees and stakeholders while reducing the risk of abuse of power and conflicts of interest, a concern that professional codes address explicitly (NSPE, 2019). Integrity is tested most when it conflicts with schedule, cost, or competitive pressure. The Boeing 737 MAX case illustrates how organizational pressure and limited transparency can undermine engineering judgment when leaders do not protect space for technical dissent (Herkert et al., 2020).

Accountability

Accountability requires leaders to take responsibility for their decisions and actions. In technological development, leadership decisions often carry significant implications for organizations and society. The distributed nature of modern engineering work complicates accountability: Mittelstadt et al. (2016) point to the difficulty of tracing responsibility when outcomes emerge from complex, multi-actor algorithmic systems, and Raji et al. (2020) argue that an accountability gap persists unless organizations embed audit processes throughout the development lifecycle. Dignum (2019) treats accountability as the ability to explain and justify decisions to relevant stakeholders. Accountable engineering leaders therefore establish clear ownership of risk decisions, maintain documentation that allows decisions to be traced, and accept responsibility when systems fail, instead of attributing failures to individual operators or to the technology itself.

Fairness

Leaders must ensure that decisions are made fairly and transparently. In the context of AI and automation, fairness is particularly important in preventing discrimination and algorithmic bias. The cases documented by Obermeyer et al. (2019) and Buolamwini and Gebru (2018) demonstrate that unfairness can be embedded in technical design choices and remain invisible without deliberate testing across groups, and Mehrabi et al. (2021) show that multiple, sometimes competing, definitions of fairness exist, so that choosing among them is itself an ethical judgment. Fairness also has an organizational face: justice is a core principle of ethical leadership (Northouse, 2021), and inclusive practices that give diverse team members a sense of belonging and the freedom to contribute distinctively (Shore et al., 2011) may increase the likelihood that biased assumptions are challenged before systems are deployed.

Social Responsibility

Engineers must consider the social and environmental impacts of technological innovations. Successful technologies should not only generate economic value but also contribute to societal well-being and sustainable development. Responsible leadership extends leaders' obligations to a broad set of stakeholders (Maak & Pless, 2006), and the four dimensions of responsible innovation (anticipation, reflexivity, inclusion, and responsiveness) provide practical means of discharging that obligation (Stilgoe et al., 2013). Professional codes reinforce this orientation by placing public welfare above other obligations (IEEE, 2020; NSPE,

2019), and the global sustainability agenda gives it a shared reference point (United Nations, 2015; World Commission on Environment and Development, 1987).

Interdependence of the values and illustrative cases

The five elements are interdependent rather than additive. Integrity is itself a component of trustworthiness (Mayer et al., 1995), accountability depends on the honesty with which risks are reported, fairness requires the willingness to be answerable for outcomes affecting different groups, and social responsibility gives these values their ultimate purpose. Table 2 illustrates how failures in these values have appeared in documented engineering cases.

Table 2

Illustrative Cases of Value Failures in Engineering and Digital Technology

Case	Documented issue	Values at stake	Source
Space Shuttle Challenger (1986)	Known technical anomalies came to be treated as acceptable risk within an organizational culture that normalized deviance	Integrity; accountability	Vaughan (1996)
Boeing 737 MAX (2018–2019)	Two fatal crashes; contributing factors included flight-control software design flaws, competitive pressure, limited transparency, and weak oversight	Trustworthiness; integrity; accountability	Herkert et al. (2020)
Health-risk prediction algorithm	Health care costs used as a proxy for health needs; equally sick Black patients received lower priority than White patients	Fairness; social responsibility	Obermeyer et al. (2019)
Commercial gender classification	Markedly higher error rates for darker-skinned women than for lighter-skinned men	Fairness; accountability	Buolamwini & Gebru (2018)

Values become effective only when translated into leadership practice. The reviewed literature suggests at least five such practices: (a) role-modelling and reinforcing ethical conduct through rewards and discipline (Brown et al., 2005; Treviño et al., 2000); (b) building ethical climates and safe channels for dissent (Detert & Burris, 2007; Edmondson, 1999; Victor & Cullen, 1988); (c) institutionalizing audit and documentation processes for algorithmic and safety-critical systems (Raji et al., 2020); (d) engaging diverse stakeholders and anticipating societal impacts early in design (Maak & Pless, 2006; Stilgoe et al., 2013); and (e) aligning projects with legal and professional standards while recognizing that these represent a minimum (IET, 2024; NSPE, 2019).

The Proposed Values-Based Engineering Leadership Model

Based on these findings, this study proposes a Values-Based Engineering Leadership Model that integrates trustworthiness, integrity, accountability, fairness, and social responsibility as core dimensions for sustainable technical leadership development. As Figure 1 shows, the model has three layers. At its center, the five core values guide the decisions of engineering leaders. Surrounding them are enabling conditions that determine whether individual values can be translated into action: an ethical organizational climate (Victor & Cullen, 1988), psychological safety and employee voice (Detert & Burris, 2007; Edmondson, 1999),

professional codes and regulatory governance (IET, 2024; NSPE, 2019), and values-oriented engineering education (Harris et al., 2019; Shuman et al., 2005). The anticipated outcomes are trust and legitimacy among stakeholders, safe, fair, and transparent technologies, and sustainable innovation that contributes to societal well-being.

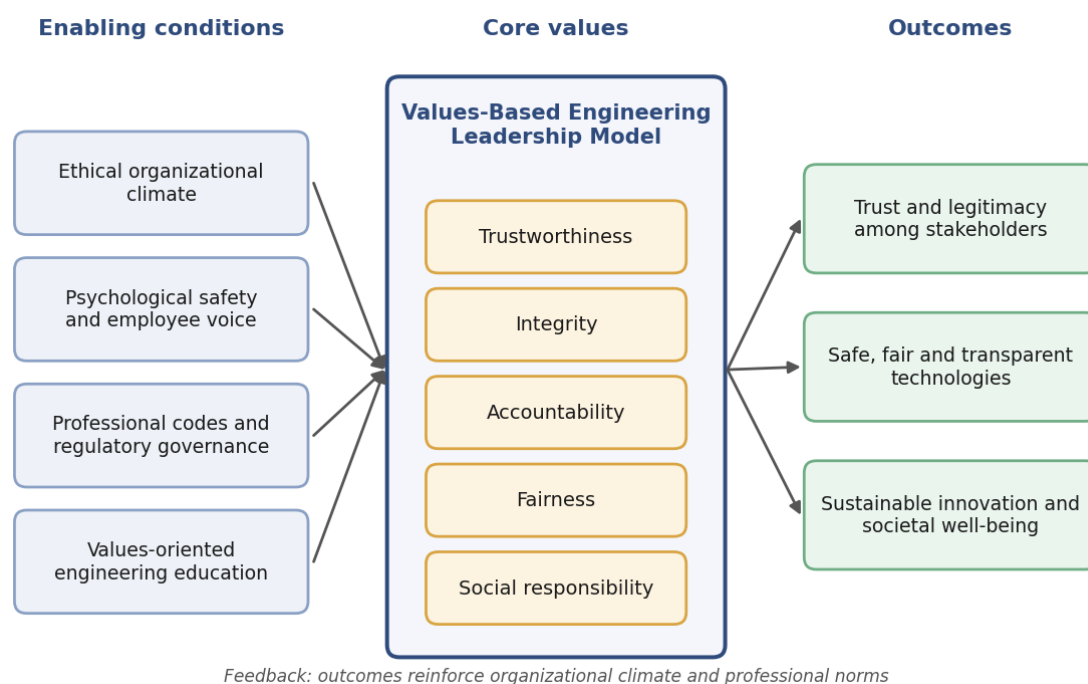


Figure 1. Proposed Values-Based Engineering Leadership Model

Note. Conceptual synthesis based on the reviewed literature.

The relationships in the model are reciprocal: positive outcomes reinforce the climates and norms in which ethical leadership is recognized and rewarded. Because the model is derived from a conceptual synthesis, the relationships it depicts are propositions to be tested rather than established effects.

Theoretical and Practical Contributions

The model contributes to the literature in three ways. First, it connects bodies of work that are usually developed separately. Ethical leadership research (Brown & Treviño, 2006; Treviño et al., 2000) explains how leaders influence conduct in general, and responsible leadership (Maak & Pless, 2006) extends that influence to stakeholders, whereas AI ethics (Floridi et al., 2018; Jobin et al., 2019) and responsible innovation (Stilgoe et al., 2013) specify what ethical technology should look like. The model places engineering leaders at the intersection, as the actors who convert such principles into organizational practice. Second, it respects the professional identity of engineers documented by Rottmann et al. (2015): because engineers tend to identify with technical mastery and collaborative problem solving, leadership values are framed as part of professional competence and not as an external managerial add-on. Third, it adds an explicit layer of enabling conditions, reflecting evidence that ethical outcomes depend on organizational climates and voice mechanisms as well as on individual character (Kish-Gephart et al., 2010).

For practice, the model can be used as a diagnostic and development tool. Educators can map curriculum outcomes against the five values, organizations can review whether their climates, reporting channels, and audit routines support them, and professional bodies can align competency frameworks and continuing professional development with them. To support empirical testing, Table 3 suggests illustrative indicators that future studies could use to operationalize each value, drawing on existing frameworks where available.

Table 3

Illustrative Indicators for Operationalizing the Five Values

Core value	Illustrative indicators	Possible grounding
Trustworthiness	Stakeholders' perceptions of the leader's ability, benevolence, and integrity; clarity of communication about system limits and risks	Mayer et al. (1995); Floridi et al. (2018)
Integrity	Follower-rated ethical leadership behaviors; consistency between stated values and decisions made under schedule or cost pressure	Brown et al. (2005); Treviño et al. (2000)
Accountability	Documented ownership of risk decisions; audit trails and independent reviews across the development lifecycle	Raji et al. (2020); Dignum (2019)
Fairness	Performance disparities tested across demographic groups; perceived procedural fairness and inclusion within teams	Mehrabi et al. (2021); Shore et al. (2011)
Social responsibility	Evidence of stakeholder engagement and societal impact assessment; alignment of projects with sustainability goals	Stilgoe et al. (2013); United Nations (2015)

Conclusion, Implications, and Recommendations*Conclusion*

Rapid technological changes require engineers to assume greater responsibilities as organizational leaders and agents of social transformation. This review indicates that technical excellence alone is insufficient to ensure organizational success. Rather, values and integrity play a critical role in determining the effectiveness of engineering leadership. The five values identified, namely trustworthiness, integrity, accountability, fairness, and social responsibility, are interdependent, and they become consequential when supported by organizational conditions that make ethical conduct possible and rewarded.

Implications and Recommendations

The study recommends that higher education institutions incorporate values-based leadership components into engineering curricula. Engineering accreditation criteria such as those of ABET already call for professional and ethical responsibility (Shuman et al., 2005), yet leadership competence also needs deliberate development (Farr & Brazil, 2009; Kumar & Hsiao, 2007). Case-based teaching using documented failures such as the Boeing 737 MAX (Harris et al., 2019; Herkert et al., 2020), together with a focus on moral courage, can help students rehearse how to act on their values under pressure. Curricula should also address AI ethics, algorithmic fairness, and data governance as part of core engineering competence (Floridi et al., 2018; Mehrabi et al., 2021).

Industrial organizations should provide leadership development programs that emphasize professional ethics and integrity. Beyond training, organizations should cultivate ethical climates (Victor & Cullen, 1988), create safe mechanisms for engineers to raise concerns (Detert & Burris, 2007; Edmondson, 1999), and adopt internal auditing practices for AI and safety-critical systems (Raji et al., 2020). Reward systems should recognize ethical conduct and not only speed or cost performance (Brown et al., 2005).

Furthermore, professional engineering bodies are encouraged to strengthen leadership competency development initiatives to ensure engineers are well-prepared for the challenges of digital transformation. Herkert et al. (2020) call for professional societies to take a more active role in ethics-related activities, and the Board of Engineers Malaysia, together with other professional bodies, is well placed to integrate leadership and digital ethics into continuing professional development. For policymakers, the National 4IR Policy's emphasis on the ethical use of technology (Economic Planning Unit, 2021) and the strengthened data protection regime (Government of Malaysia, 2024) provide a regulatory foundation. However, evidence that AI ethics guidelines often lack enforcement mechanisms (Hagendorff, 2020) and diverge in implementation (Jobin et al., 2019) suggests that policy should be complemented by leadership capability and organizational accountability mechanisms.

Limitations and Directions for Future Research

This study has limitations. As a conceptual review, it does not provide empirical evidence for the relationships proposed in the model, and the literature on which it draws is dominated by research from Western contexts, which may limit transferability to Malaysian engineering organizations. Future research should employ empirical approaches to examine the relationship between values-based leadership and organizational performance, innovation outcomes, and employee well-being within engineering contexts. Survey-based studies could validate measures of the five values and test the enabling conditions in the model, qualitative case studies in Malaysian engineering firms could examine how leaders handle ethical dilemmas involving AI and data, and cross-cultural comparisons could clarify how Malaysian and Islamic ethical perspectives, including the concept of *amanah*, shape the interpretation of these values.

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