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# Engineers as Agents of Technological Change: Ethical Challenges of Technology Adoption

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## Abstract

Technology adoption involves using new or existing technologies in various settings, which increases the opportunity for ethical challenges. Technology adoption implicates engineering ethics, as engineers both create and use technologies for themselves and others. Agency is a critical factor in ethical analysis of the adoption of technological change. Engineers must design, develop, and deploy technologies ethically, and also adapt to the changing technological environment. Technology adoption poses ethical challenges for engineers, such as respecting stakeholders' rights and interests, while balancing benefits and risks. Technology adoption may also implicate engineers' identity, values, and competencies, especially with emerging technologies like artificial intelligence. This paper explores the ethical issues and dilemmas of technology adoption for engineers, and the consequences of ethical failures. The paper also suggests implications for engineering ethics education, such as using technology adoption scenarios and cases, fostering ethical awareness, and reasoning, and promoting a culture of ethical reflection and action.



## Keywords

Technology Adoption, Ethics


## The Scope, Scale & Pace of Technology Adoption

Engineers are deeply engaged in the "how" of technology – delivering new functionality to society through products, services, infrastructure, etc. Engineering students are burdened with the acquiring the knowledge and skills to understand current technology deployments, while preparing for future technology developments. In an era of increasing technology specialization, engineers, and engineering students are confronted with an ever-increasing volume of technological advances. The ASEE mission statement on ethics in engineering education[14] refers to helping students use their role as "moral agents" with responsibilities for helping develop solutions to ethical problems they encounter. A mono focus on the technological "how" can distract from the need to consider the 4W's – "Who", "What", "Where", "When" in applying that technology, with an assumption that the new technology is always, somehow, "better". This need for focus can be particularly pressing in commercial practice when attempting to support rapid growth of market share (e.g., Blitzscaling[1]).

Technology adoption is an individual choice, but may be affected by larger scale initiatives, e.g., Digital Transformation. Digital transformation is a term that describes the process of using digital technologies to create new or modify existing products, services, and operations in order to deliver value to customers and meet changing business and market requirements. It is impacting a broad variety of economy sectors according to Zaoui and Souissi[2]. Digital Transformation is not just about technology adoption[3], but rather a careful consideration, and matching of technology adoption choices with organizational goals. Individual technology adoption decisions can be seen as more tactical, while more strategic digital transformation strategies are being adopted in commercial organizations as well as higher education institutions[4]. Various administrative responses to the COVID-19 outbreak accelerated a digital transformation of the workforce[5] with many people working from home. The social dimension is also impacted by technology with the rise of social media. As of 2018, the users of Facebook and other social media platforms were numbered in the billions[6]. While Weller[7] argues for the historical ubiquity of surveillance, we are living in a time when more information about the everyday activities of more people than ever before, is gathered, collected, sorted and stored by multiple organizations – both state[8] and private[9] actors.

Considering the daily life of the man in the street, it is difficult to identify an aspect of which has not been impacted by technology. When focused on a particular technological problem it is often difficult to foresee the potential impact; but that does not absolve the need for consideration. The impact of technology adoption decisions is often considered from limited personal, anecdotal perspectives. What may be a minor impact individually may become much more significant when scaled to the general public population. The reasonableness of the pace of change seen by the general public is certainly contestable, and subject to variation with individual circumstances, resources, value etc. It may be a minority perspective, but for some portion of the population, slowing the pace of change can be seen as a desirable thing in itself (See e.g., Woodhouse[10]). For Steen[11], a slowing of the pace of innovation is rather a consequence of allowing time for reflective consideration of "uneasy questions, vulnerable experiences, awkward moments and uncertainty".

People, organizations, and even governments adopt new technology for various reasons, but mainly to improve their efficiency, competitiveness, adaptability, and growth. To realize these benefits, however, people, organizations, and governments need to overcome the barriers and challenges of adopting new technology, such as complexity, resistance, cost, risk, and skill gaps. The technology adoption process is the sequence of steps that a potential user goes through before deciding to adopt or reject a new technology. The technology adoption process can vary, depending on the type of innovation, e.g., whether it is disruptive or incremental etc. Adopting new technology can be a challenging process for many people and organizations.

New technology often requires new skills, new processes, new mindsets, and new goals. These changes can create unfamiliar situations where users have no previous experience or guidance to rely on. Ethical frameworks are relevant to technology adoption because they can help ensure that the technology is used in a way that respects human dignity, rights and values, and that minimizes potential harms and risks to individuals, groups, and society. Ethical frameworks can enable comparison technology adoption decisions in terms of accountability, transparency, fairness, beneficence, and non-maleficence[12]. New technology can create new forms of activities, transactions, or interactions that are not covered by existing laws or regulations. The emergence of e-commerce, online platforms, and cryptocurrencies has raised new issues of consumer protection, taxation, competition, and privacy that require new legal frameworks.

**Agency in the Adoption of Technological Changes**

Agency generally refers to the ability and willingness of individuals or groups to act independently and make their own choices. Agency can be influenced by various factors, such as motivation, attitude, skills, knowledge, resources, culture, and context. Agency can also affect how people perceive, adopt, and use technology. Agency can also affect how technology is designed, implemented, and evaluated to meet the needs and preferences of users. Ethical frameworks (e.g. Kantian philosophy) that value the individual's right to choose for themselves would support the need for agency in that personal moral responsibility exists as a result on one's own decisions.

At any given moment in time, multiple people are making decisions to adopt a particular technological change with varying degrees of forethought or analysis, and impact. A personal technology adoption decision will obviously affect that person but may have some impact on others. If you are interacting with a second person and they decide to adopt a particular technology, that will likely also have some impact on you, and you may be forced to respond to that technology adoption decision. If you are simply observing two other people where some new technology is adopted, this may not have an immediate impact on you but may be relevant for future consideration. One can also consider cases where the technology adoption decision is more remote e.g., within Dunbar's number[13], within an organization, within a geographic jurisdiction, etc. The more remote the decision to adopt the technological change, the less agency one has in that decision. Engineers make a lot of technology related decisions. Some of those decision impact primarily themselves. Other decisions can affect very remote persons unknown to that engineer.

In many published discussions of technology, the language used implies some degree of personification that can be problematic[15]. Personification is a literary device that attributes human-like qualities to non-human entities. In the context of technology, personification refers to the practice of imbuing technological devices with human-like characteristics, such as emotions, personality traits, and even physical features. There are some examples where technologies have been developed to explicitly mimic human capabilities[16], but the majority of technologies do not have this as an explicit objective. The advent of "smart speaker" consumer devices with speech capabilities[17] exacerbates this trend as prior public awareness largely restricted speech capabilities to humans.

Generative AI extends this trend even further through both the apparent "creation" of content that prior public awareness largely attributed to humans, and explicit efforts towards *"personality"* associated with such generative efforts[18]. AI tools are also being considered in roles (e.g., public administration[19]) that can impact the public without them even being aware of such tools being used. While personification of technological devices is mostly a literary device, it can cause confusion when considering ethical implications. Humans are the subject of ethical enquiry where technological devices are not. In most jurisdictions, technological devices – even autonomous ones - are not even recognized as having "legal personality". A recent exception exists in some states for Decentralized Autonomous Organizations (DAOs) as a form of corporation[20]. In general, it is the operator or developer of the technological device that is liable for any tortious consequences of its use, rather than the device itself.

Technology evolution is a term commonly used in the engineering literature to provide a narrative describing feature changes or trends (e.g., "5G technology evolution"[21]). From a historical perspective, the term "technology evolution" refers to the development of systematic techniques for making and doing things over time, by various groups of people (usually engineers). The term also draws an analogy to the origin of new technology from the mechanisms of evolutionary biology whereby technology variations are "selected" and retained in widespread use. The “selection” of technology is usually done by someone other than the developer - the consumer of the technology (in a market economy), or some industrial policy maker (in more centralized economies). Other narrative styles (e.g., “technological parasitism”[22], “Kondratiev waves”[23], etc.) have also been proposed to describe technology evolution at a macro scale as emergent behavior. From an ethical perspective, the underlying technology still lacks agency as it is the humans around it that are making decisions to develop or adopt it for further use.

## Engineering Roles in Technology Adoption

Pathways for engineering careers are increasingly diverse with varying emphasis on professional competencies[24]. While engineering competencies are associated with innovation and technology development, personality assessments are often at odds with the personality attributes associated with intrepreneurship or entrepreneurship[25]. There have been some efforts towards the development of a consensus view of an “engineer profile” to collect these various attitudes and competancies[26,27]. These lists of competencies, however, rarely focus on technology adoption, or business roles more explicitly focused on technology adoptions such as product management[28,29].

And yet engineers are commonly seen as playing a crucial role in the adoption of new technology. Engineers are deeply engaged in designing, developing, and testing new technologies, products and services[30]. They also help identify the most efficient and effective methods to implement new technologies in various industries, often working with other professionals to ensure that new technologies are safe, reliable, cost-effective, etc. Engineers are also often engaged in the development of new standards and regulations for emerging technologies. Knowingly, or otherwise, the public often relies on engineer’s opinions as to the technology’s safety, fitness for purpose, effectiveness, etc. Engineers may have passive responsibility for following some course of action that leads to accountability or blameworthiness for some bad outcome. Alternatively, engineers can have more active responsibility[31] when they display the agency and autonomy in considering professional and social norms and potential consequences before acting. The perception of the role of ethics in engineering matters[32] for both reputation of the profession and the ability to attract new entrants.

## Ethical Challenges in Technology Adoption

Ethical failures concerns are often raised after technological failures, but they can equally arise after technological triumphs. The digital transformation of society builds on a succession of technological triumphs by engineers in computing, communications, artificial intelligence etc., but exposes ethical concerns in areas such as privacy, social equity, exacerbated power concentration etc. Rapidly scaling technology adoption can also lead to a period of rapid job loss through automation as the economic impact of the technology adoption ripples through the broader economy. Product design choices can also impact the user throughout the product lifecycle with constraints on the user’s rights to repair[33], or resell[34]. The nature and scope of digital transformation is becoming an ethical concern of nations under the digital sovereignty[35] rubric. There is no less a concern at an individual level for self-sovereignty[36] in the face of overreach by national authorities[37], and other private organizations[38].

The purpose of ethical enquiry can impact the types of challenges faced in technology adoption decisions. One approach is to consider whether a sword or shield metaphor applies to the purpose of the ethical enquiry. Ethics can be used as a sword when someone uses ethical principles to attack or accuse another person or organization. If an engineer (or engineer's company) is accused of unethical practices related to technology adoption, the accuser may use ethical principles to argue that the company's actions are wrong and should be stopped. Ethics can be used as a shield when someone uses ethical principles to defend themselves against accusations of wrongdoing. For instance, if an engineer (or engineer's company) is accused of unethical technology adoption practices, the company may use ethical principles to argue that their actions are justified and not unethical. There are several reasons why someone might make ethical accusations regarding technology adoption, whether they believe them to be true or not[39]. These can include:

- *Moral concerns*: Some people may make ethical accusations because they believe that the technology in question is morally wrong or violates their personal values.
- *Social responsibility*: Others may make ethical accusations because they believe that the technology has negative social consequences, such as harming the environment or perpetuating social inequality.
- *Legal implications*: Some people may make ethical accusations because they believe that the technology violates laws or regulations.
- *Competitive advantage*: In some cases, companies may make false ethical accusations against their competitors in order to gain a competitive advantage.
- *Public relations*: Finally, some people may make ethical accusations for public relations purposes, such as to draw attention to a cause or to improve their own image.

It's important to note that making false ethical accusations can have serious consequences and should be avoided.

## Consequences of Ethical Failures in Technology Adoption

Failing to educate engineers about ethics can have serious consequences for the public, the environment, the profession, and the engineers themselves. Some of the possible consequences are:

- **Engineering disasters:** When engineers do not follow ethical standards or codes of conduct, they may compromise the quality, safety, or reliability of their designs, products, or services. Ethical failures, whether categorized as human factors or design flaws, can lead to engineering failures that cause harm, injury, or death to people, animals, or property. For example, the collapse of the Hyatt Regency walkway in 1981, which killed 114 people and injured 216 others, was partly attributed to a lack of communication and oversight by the engineers involved[40].

- **Legal liability:** When engineers violate ethical principles or laws, they may face legal consequences such as lawsuits, fines, penalties, or criminal charges. For example, some of the most common ethics violations for professional engineers are misrepresentation, fraud, negligence, and conflict of interest[41]. The business practices and frequency of legal liability exposure varies across technology areas of engineering practice.

- **Professional reputation:** When engineers act unethically or irresponsibly, they may damage their own reputation as well as the reputation of their employer, client, or profession. They may lose the trust and respect of their colleagues, customers, regulators, or the public. They may also face disciplinary actions from their professional associations or licensing boards. For example, the National Society of Professional Engineers (NSPE) has a Code of Ethics for Engineers that sets forth the ethical obligations of its members and provides a process for investigating and resolving complaints. Other technical specialty branches of engineering have similar organizations and codes of ethics.

- **Moral responsibility:** When engineers fail to consider the ethical implications of their work, they may neglect their moral duty to protect the public health, safety, and welfare. They may also disregard the rights and interests of other stakeholders, such as future generations, or marginalized groups. They may also violate their own personal values and principles. Moral self-perceptions can activate self-regulatory behavior, and identity concerns[42].

**Technology Adoption (e.g., AI) also impacts Engineers in Diverse Technology Fields**

The engineering industry is constantly evolving, and the adoption of new technology has a significant impact on engineers across all fields. New ways of collaborating and innovating can speed up product development and rein in R&D costs[43]. Manufacturers have added more and more sensors to their products as the cost has come down and advanced analytics become available to interpret the data. Engineering is becoming more data-driven as a consequence of technological advancements such as IoT[44]. Digital transformation is applicable across all fields of engineering, not just the communications and computing fields that are predominately associated with the topic[45]. Privacy by Design (PbD) principles, as an example, refer to ICT systems[46], but (e.g. through IoT) other engineering fields (e.g., Civil[47], Mechanical[48], Water[49]) may also implicate privacy. PbD assumes Privacy as a value (and many ethical frameworks value privacy). Methods for evaluating technology developments against privacy principles and values are not widely standardized[50] – they rather rely on some *Privacy Impact Assessment* to capture the analysis of whatever analysis (if any) has been performed[51].

Consider the adoption of AI across the branches of the engineering profession. AI is reportedly broadly applied in multiple branches of engineering e.g. Civil[52] , mechanical[53], electrical[54], chemical [55] engineering. The ethics of AI usage is widely discussed in multiple bodies and appears to be converging on some general principles, but these seem insufficient to ensure that the AI tools themselves are “ethical” [56, 57]. Hence the responsibility for the ethical use of these tools remains with the engineer using them.

**Implications for Engineering Ethics Pedagogy**

Interest in engineering ethics education developed some momentum in the 20$^{th}$ century, but at that time the majority of US engineering students were not required to take an ethics related class[58], though that has changed more recently. There are several pedagogies used in engineering education for ethics. One example is a complete, university course on engineering ethics – alternatively, some programs seek to embed ethics discussion across the curriculum[59]. There is, apparently, neither a consensus throughout the engineering education community regarding which strategies are most effective towards which ends, nor which ends are most important[60].

The most common methods for integrating ethics into engineering involving exposing students to ethical codes/standards, utilizing case studies, and discussion activities. Nearly half of the articles identified by Hess and Fore's 2018 survey[60] had students engage with ethical heuristics or philosophical ethics; and they noted proposals for a variety of ethical frameworks including feminist ethics, humanitarianism, sustainability, virtue ethics. The variety of goals, approaches and evaluation methods does not appear to have yet congealed into consensus "best practices" [61]. Jenkins[61] argues that it is unclear whether teaching ethics to engineering students will in fact change or the influence the personal behavior, beliefs, or actions of engineers and corporate managers at critical junctures. In their survey of student attitudes, Howland et al.,[63] hypothesize a pattern of self-selection into experiences, indicating the difficulty of developing impactful ethics interventions, given that students arrive at university with pre-existing knowledge and perceptions about ethics and morality.

Ethics or moral philosophy classifies human behavior as right or wrong based on some set of governing principles. Technology is the application of scientific knowledge for practical purposes whether as infrastructure, products, services, software etc. Despite literature personifying technology, ethical considerations apply to the humans interacting with technology rather than the technology itself. Technologies are developed, adopted, used, adapted, and deprecated by humans for various purposes. Technology adoption refers to the process of accepting, integrating, and using new technology in society. c Legal structures may limit legal liabilities at an organizational level but are no hindrance to ethical consideration of the conduct of humans, and organizations of humans. Employee engineers, as well as those in individual practice, are adopting new technologies personally, in their organizations, and in a larger societal context.

Technology adoption and digital transformation is also impacting engineering education[64,65,66], and higher education more broadly[67]. Some of the technologies affecting this digital transformation include learning management systems coordinating pedagogical delivery; mobile devices and cloud computing enabling remote pedagogical delivery at scale; IoT, Analytics and Machine Learning technology adoption transforming the practice of engineering across multiple engineering disciplines; and immersive Virtual Reality/ Augmented Reality transforming the experience of engineering students beyond previous simulation tools.

Engineers are changing the world through the technologies they develop and deploy. While the profession may have broader aspirations, individual engineers are limited to the technology decisions they actively make, or passively accept. Ensuring those decisions are "ethical" requires individual engineers to have some awareness of potential ethical issues and skill in ethical reflection. To achieve the broader social aims of the profession, as expressed in the various professional codes of ethics, requires the development of a culture of ethical reflection and action. Engineering ethics pedagogy has a role in building and maintaining that ethical culture of professional engineering.

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