Global Philosophy (2024) 34:2
https://doi.org/10.1007/s10516-024-09706-5

ORIGINAL PAPER

A Holistic Approach to Macro-Ethics of Technology: A Contribution to Mitcham's Big Idea

Mohammad Sobhan Jalilian[1] · Mahdi Fatehrad[2] · Javad Akbari Takhtameshlou[3]

Received: 16 September 2023 / Accepted: 15 March 2024

Abstract

Carl Mitcham has recently pointed out that the current approach to the ethics of technology has failed to solve large-scale socio-ethical challenges in the technological world, such as climate change. He then suggests that, in the face of an iceberg of issues regarding technological development, philosophers should recognize the intellectual heritage of the classical philosophers of technology to better deal with the escalating crises that threaten humankind. While Mitcham's proposal is inspiring, there are several lacunae in his work. In this paper, we contribute to Mitcham's idea by developing it and filling the important gaps. Our efforts have led to a new style of *holistic* thinking about the ethics of technology, according to which it is necessary to focus on the *system* of technologies as a *whole* (while not ignoring individual technologies, of course) to understand and address issues related to technology development.

Keywords Technology · Macro ethics · The empirical turn · Mitcham · Heidegger

This article's material and research are mostly taken from the master's thesis written by Mohammad Sobhan Jalilian and supervised by Javad Akbari Takhtameshlou at Sharif University of Technology.

✉ Javad Akbari Takhtameshlou
jakbarit@sharif.edu

Mohammad Sobhan Jalilian
sobhanjalilian@gmail.com

Mahdi Fatehrad
fatehrm@sharif.edu

[1] Department of Philosophy, University of Alberta, Edmonton, Canada

[2] Sharif Policy Research Institute, Sharif University of Technology, Tehran, Iran

[3] Department of Philosophy of Science, Sharif University of Technology, Tehran, Iran

Published online: 08 April 2024

1 Introduction

Technology has a long history, dating back to the beginning of human civilization. Despite this, the study of technology as a philosophical topic is a comparatively new phenomenon. Although the writings of philosophers like Francis Bacon (1561–1626), Ernst Kapp (1808–1896), and Karl Marx (1818–1883) include significant insights on technology, it was not until the mid-twentieth century that technology became one of the main subjects of philosophical inquiries. During this period, pioneer thinkers like Karl Jaspers, Martin Heidegger, Herbert Marcuse, and Jacques Ellul examined the nature of technology and its relationship with fundamental concepts such as existence, truth, rationality, and determinism. But the philosophy of technology has not been limited to the ideas of these 'classical' philosophers. In fact, this field has evolved through at least two subsequent generations: the second-generation philosophers who made the 'empirical turn' in philosophy of technology and the third-generation philosophers who are currently developing the idea of 'moralizing technical artifacts' through the design process. As we shall see in the next sections, each period has its own unique characteristics that distinguish it from others.

With these distinctions in mind, Carl Mitcham (2020), philosopher and historian of technology, has recently proposed an inspiring idea according to which philosophers should recognize the intellectual heritage of the *classical* philosophers of technology to better deal with the growing crises that threaten humankind. Mitcham points out that the current approach to the ethics of technology has not been able to solve *large-scale* socio-ethical challenges in the technological world, such as climate change and ecological devastation. He believes that this inability is the result of a break from the classical way of thinking about technology. He explains that there is a new tendency among philosophers to "abandon any broad claims to talk about Technology (with a capital T) in favor of a much more narrowed focus" on technological regionalizations such as "environmental ethics, biomedical ethics, computer ethics, information ethics, engineering ethics, research ethics, nanoethics, neuroethics, and more" (2020, 594). According to Mitcham, these philosophers, influenced by the empirical turn, develop a new approach to the ethics of technology that prioritizes small efforts to reform technologies over big, revolutionary ideas. However, "the impotence of [these] small efforts" has gradually become evident as big problems have not only remained but also been deteriorating during the recent decades (2020, 594). He then suggests that philosophers should think in large-scale terms once again in order to contribute to "world-historical transformations" (2020, 596), given the iceberg of issues that arise from technological development. To do so, he points out that in the trajectory of critical reflections on technology, there is "a big picture historical heritage that deserves to be recognized if not recovered" (2020, 595). Particularly, he cites the classical works in philosophy of technology such as Heidegger's 'The Question Concerning Technology' (1954), Ellul's *The Technological Society* (1967), Marcuse's *One-Dimensional Man* (1968), and Mumford's *The Myth of Machine* (1967) as examples of works that contain big ideas and deserve to be considered once again (2020, 595).

While Mitcham's proposal is inspiring, there are several lacunae in his work. In this respect, two issues are specifically important for our further discussions of his ideas. First, Mitcham does not identify what the fundamental shortcoming is within the current approach to the ethics of technology, which makes it a defective and inefficient way of dealing with the formidable challenges of the contemporary world. In other words, he does not point out why the small efforts of the third-generation philosophers to moralize technology have not been fruitful and why methodological changes in the ethics of technology, for instance, open the way for a world-historical transformation. Second, while Mitcham invites philosophers to rehabilitate themes from the classical philosophy of technology, he does not make it clear which aspects of the classical approach should be adopted and which should be abandoned (if any). In any case, given the findings of empirical studies, a number of classical ideas have faced harsh criticism, and this fact makes it difficult to revive them. Therefore, if one finds value in those classical themes and ideas, she should either explicitly challenge the empirical findings or provide a different interpretation of classical ideas that is at least consistent with empirically-informed philosophy.

In this paper, we want to offer a contribution to Mitcham's idea by developing it and filling the important gaps mentioned above. To do this, we take three main steps. Below, we explain why the currently dominant approach to the ethics of technology is inadequate for addressing global challenges like environmental degradation. This approach, in our view, does not pay enough attention to all the potential roots of these crises, nor does it provide a comprehensive solution for overcoming them. We also acknowledge that the classical way of thinking about technology, while providing significant clues in the search for an alternative approach, is merely a point of departure rather than a destination, as we believe that certain elements of the classical philosophy of technology should be reinterpreted while others should be abandoned because of what we know from empirical studies. Finally, by reinterpreting some aspects and ideas of the classical approach, we suggest an alternative approach to the ethics of technology, according to which a supplementary research program addressing big, yet frequently overlooked, questions related to technology development should be followed.

To meet these objectives, an analytic overview of the history of philosophy of technology is needed to provide the necessary background for reinterpreting and, in fact, synthesizing themes and ideas in an alternative approach. Therefore, we will begin by outlining the main characteristics of the classical approach. To do so, while we will focus primarily on Heidegger's influential article 'The Question Concerning Technology' as one of the most important classical works of that period, we will also refer to other works like Jaspers' and Marcuse's to ensure that our description is somehow comprehensive. Next, we will look at why and how second-generation philosophers developed an empirically-informed philosophy that they used to criticize classical thoughts. Then, we will take a look at the idea of moralizing technical artifacts that third-generation philosophers have taken seriously in recent decades. After that, we will explain why this approach to the ethics of technology is inadequate for addressing the socio-ethical challenges raised by technology. Finally, we will propose what can be called 'the *holistic* approach' to the ethics of technology.

2 First Generation: The Classical Approach

This section outlines the most important methodological and content-related features of classical theories of technology. Even if not all classical works contain these features in the same way, they share a family resemblance in their approach to technology. The objective is to identify central themes that highlight similarities among classical theories.

The most noticeable feature of the classical approach is its pessimistic attitude toward technology. This means that early philosophers generally portrayed a "gloomy picture" of the technological world (Verbeek 2005, 4). For instance, Jaspers in *The Origin and Goal of History* explicitly pointed out "the demonism of technology" (1965, 122), and Heidegger described technology as the "greatest danger" to humankind (1977, 28). In this approach, technology is generally depicted as an independent, pervasive power that prevents human beings from establishing an authentic relationship with reality and genuine life. In general, the idea of 'alienation' due to the prevalence of technology was a common thought during that period.

The notion of alienation is present in Marx's writings, but first-generation philosophers of technology use this concept in a more comprehensive and nuanced way. In his analysis of the relationship between work and capitalism, Marx argues that capitalists, to maximize their net profits, employ machines to impose their will on the working class. More specifically, they use machines to deskill workers and alienate them from the nature of work; as a result, they turn professional workers into replaceable laborers that cannot resist the will of the higher class manifested in demands like increasing working hours and decreasing wages (MacKenzie 1984, 480–489). Nonetheless, when the first-generation philosophers of technology use this term, they refer to the alienation of human beings from the reality of the world and also from authentic life. In other words, the classical approach discusses the alienation problem from both an existential and phenomenological standpoint. In the existential approach, thinkers point out the one-dimensionality of human lives and the lack of ethical and spiritual values in the modern age. They also express their profound concerns regarding consumerism, treating human beings as a means, and converting humankind into the capitalist cogs in a technological society. In the phenomenological dimension, these thinkers talk about the concealment of being as well as the neglect of other ways of being in the world.

This pessimistic attitude toward technology, as Brey points out (2010, 36–38), is a reaction to the optimistic atmosphere of progressivism in the Renaissance and the Enlightenment Age. During those times, thinkers such as Francis Bacon urged that humankind develop science and technology to harness the power of nature and establish the promised paradise on earth. However, following the industrial revolution, when these ambitious ideas were to some extent realized, the negative effects of progressivism and technological development, such as environmental pollution and the development of destructive weapons, gradually became apparent. Under such conditions, philosophers started to criticize the simplistic

understanding of technology and to develop critical theories that debate the relationship between technology and fundamental concepts. During such discussions, these philosophers took a normative stance and expressed their negative attitudes toward technology. Therefore, the presence of a negative normative attitude is a common feature in classical works.

The second feature of the classical approach is the transcendental style of thinking about technology. That is to say, rather than focusing on technology itself, the first-generation philosophers focused more on the necessary condition of the possibility of technology (Achterhuis 2001, 3). For example, when Heidegger was talking about the essence of technology, he took a step back from technology and discussed the ontological-historical horizon that makes modern technologies possible. According to Heidegger, in the modern age, reality has been revealed in a particular way, which calls human beings to use their will to power in order to invade nature and master the world as an eternal source of energy. In this way of encountering reality, the world is considered something controllable and computable, and everything is reduced to its causal affordances. As a result, the Rhine River is no longer viewed as an inspirer of artistic spiritual works, as it has appeared in Holderlin's hymn, but as a supplier whose potential energy "can be extracted and stored" by building a hydroelectric plant (Heidegger 1977, 16). Heidegger named this way of revealing or encountering 'Enframing' (in German Gestell), thinking it to be "what lies behind or beneath modern technology" (Mitcham 1994, 52), on which the existence of different technical artifacts depends. Therefore, Heidegger's main discussion is about something non-technological that functions as the precondition of technological activity. It is worth mentioning that such a transcendental approach is found in other classical works as well. For example, Jaspers's philosophy of technology is mainly about the socio-cultural system that leads to technological development (Verbeek 2005, 17), and Marcuse (1968) has principally examined technological rationality as something non-technological that is wholly present within technological practices.

Since classical philosophers of technology tended to focus more on the transcendental condition of technology than the technology itself, their approach to technical artifacts and technological practices is somewhat abstract and general. In other words, as the underlying structures of the technological world are the first research priority in the classical approach, the first-generation philosophers did not pay serious attention to how different technologies are and how they function in various contexts. Consequently, they only offered an abstract and general description of technologies and technological practices, so that their judgments "were couched in blanket terms of 'Technology' with a capital T, leaving no room for different kinds of descriptions of different kinds of technologies" (Verbeek 2005, 4). Therefore, 'thinking about Technology with a capital T' is the third feature of the classical approach.

The fourth feature of the classical approach is a belief in two distinct yet related ideas: technological determinism and the autonomy of Technology. These two ideas are related in the sense that both explore the human-technology relationship.

Technological determinism asserts that technology has a profound impact on human life, transforming society and affecting various aspects such as social, cultural, political, and economic structures and values. It comes in strong and soft

versions, with the former claiming that technological developments necessarily transform society and lead to specific consequences, while the latter subscribes to a more contingent idea that society may be changed due to technological developments. Philosophers of the first generation acknowledged the strong form of technological determinism and warned against the dystopian outcomes of technological advancements. Heidegger's reflections, for instance, highlight some treacherous consequences of Enframing's continued dominance. First, he warned that this dominance could lead to forgetting other ways of encountering reality and experiencing a more primal truth (Heidegger 1977, 28). The second threat, which may be referred to as 'the death of things', is linked to Enframing's reductionist approach. This approach involves de-worlding, slaughtering, and reducing all identities to their potential causal capabilities. For instance, a reductionist view ignores the tree-ness of a tree, including its aesthetic dimensions, and treats it as nothing more than a bunch of lumbers for technical use. Furthermore, Heidegger cautioned that this view not only obscures the richness of being but also leads to an attitude where humans treat each other merely as a means of energy and source, contributing to a concealment of the richness of being (Heidegger 1977, 27).

The idea of autonomous technology reverses the direction of the discussion. According to this idea, technology is an independent, autonomous power that functions out of human control and evolves according to its own rules. In other words, technology has its own particular logic of development, so it is not affected by humans' intentions and is completely independent of social and political orders. Though the idea of autonomous technology has been explicitly discussed in Ellul's writings (1967), its traces can be found in other classical works as well. For example, in *The Question Concerning Technology*, Heidegger pointed out that the revelation of being is not human handiwork and that "man does not have control over unconcealment itself, in which at any given time the real shows itself or withdraws" (1977, 18). Therefore, the essence of technology as a way of revealing or unconcealing the real, in which nature is conceived as standing-reserves, is independent of humankind; Enframing is a civilization given that human beings only respond to its calls (1977, 18).

The commitment to the idea of autonomous technology and the belief in the pervasive power of technology results in a relative passivity in dealing with technology, which is the fifth characteristic of the classical approach. This passivity arises from the recognition that full emancipation from technology requires a fundamental revolution beyond human control, as proposed by Heidegger and other first-generation philosophers. To mitigate the dangers of technology, Heidegger suggested questioning its essence (1977, 3), participating in art, and avoiding immersion in technical artifacts (1969, 45), but he also acknowledged that these efforts alone could not lead to profound change. In his view, "human activity can never directly counter this danger. Human achievement alone can never banish it" (Heidegger 1977, 33), since Enframing as a civilization given is out of human control. Instead, he believed that only a saving power beyond human achievement could overcome technological challenges, stating in his last interview with Der Spiegel that "only a God can save us."

The last characteristic discussed here is related to the essentialist approach of classical philosophers. First-generation philosophers, as should be obvious, have

primarily focused on the 'essence' of modern technology, to which they attribute some features like autonomy and determinism. Though their conceptions of 'essence' may differ somewhat from those of philosophers like Aristotle and Plato, it is difficult to deny that classical philosophers find a commonality among modern technologies. This commonality is like a disseminated spirit that is found in different technologies, upon which the unification of such technologies depends. Therefore, these thinkers offered a uniform description and judgment of all technical artifacts and technological practices as manifestations or instantiations of a more substantial thing called the essence of technology. In the case of Heidegger, Andrew Feenberg writes:

> Heidegger's argument is developed at such a high level of abstraction he literally cannot discriminate between electricity and atom bombs, agricultural techniques, and the Holocaust. All are merely different expressions of the identical Enframing, which we are called to transcend through the recovery of a deeper relation to being. (Feenberg 2000, 297)

Therefore, the sixth feature of the classical approach, which has its origins in essentialist theories, is to offer a monolithic description and judgment of technologies.

3 Second Generation: The Empirical Turn

Despite the fact that first-generation philosophers played an unprecedented role in the development of philosophical reflections on technology, the next-generation philosophers found the classical way of thinking unsatisfying. As we explained, classical philosophers mainly dealt with transcendental questions and talked about the underlying structure necessary for technological development. However, second-generation philosophers maintained that one cannot get a *comprehensive* understanding of technology from discussions restricted to transcendental questions. Hence, these philosophers emphasized the need for the philosophy of technology to broaden its scope of inquiry. According to them, other topics such as engineering practices (like the design procedures), technological knowledge, the role of technology in human actions and perceptions, analyzing technological concepts like 'function', as well as paying attention to contexts in which technologies function, were philosophically important to understand the technology and should not be considered merely peripheral issues (Vermass et al., 2011). These philosophers also criticized the classical approach from a methodological point of view. They held that thinking about Technology with a capital T was not only insufficient for understanding technology but also misleading in this regard. Such an approach is insufficient because it only provides an abstract understanding of technology that covers the facts about technological varieties (Briggle 2016, 168). It is also misleading since such a non-discriminating view has led to monolithic judgments of technologies, which in turn have paved the way for the total pessimism typical of classical theories.

Considering the above-mentioned objections, philosophers of the second generation developed an alternative approach according to which philosophers should

leave their ivory towers and examine various technologies in a concrete way. In this new approach, researchers are encouraged to scrutinize technical artifacts and, rather than discussing Technology in an abstract manner, to investigate the social consequences of specific technologies in specific contexts. In other words, while classical philosophers using an abstract transcendental approach had offered philosophies "beyond things", second-generation philosophers concluded that they should come closer to technologies, open their black box, and offer philosophies derived "from things" (Verbeek 2005, 13 & 97). Hence, during this period of philosophizing on technology, it was deemed essential to conduct case studies in order to develop an empirically-informed philosophy. This movement is often referred to as the 'empirical turn'.

The empirical turn seems to have had two main sources of inspiration: Quine's idea of evaluating philosophical ideas based on empirical findings (Kroes & Meijers 2016, 15) and Kuhn's urging to pay attention to the actual practices of scientists (Franssen et al. 2016, 2). Quine (1953) argued that all knowledge is empirical and that there is no sharp distinction between philosophy and science. In his view, philosophy feeds on experience, which means that philosophical hypotheses, such as those regarding technological determinism, may be tested by empirical studies. Kuhn (1962) broadened the scope of the philosophy of science by suggesting that, in order to grasp the nature of science, philosophers should consider its practice and the role of external factors, which led to the importance of social studies in this field. Second-generation philosophers of technology did the same thing and began paying attention to the actual practices of engineers and the social studies of technology. This led to the transformation of the philosophy of technology into a descriptive discipline that focused on understanding technology rather than assessing its socio-ethical consequences.

In light of the empirical turn, many classical ideas were criticized severely. Most importantly, many philosophers acknowledged, based on empirical case studies, especially those done under the flag of 'social construction of technology,' that the idea of Technology as an independent, autonomous essence that necessarily directs society towards a specific destination is completely implausible. In other words, second-generation philosophers criticized the ideas of essentialism, the autonomy of technology, and technological determinism.

Second-generation philosophers, such as Don Ihde and Andrew Feenberg, are anti-essentialists in general. They believe that technical artifacts do not possess an independent, pre-established essence that constitutes their identities. Instead, their identities as technologies stem from particular human contexts. As there is no such thing as 'mere consciousness', but rather, consciousness is always 'consciousness of something', the same may be said of tools: there is no 'mere tool', and tools are always for doing something. Tools always have functions, and those functions are dependent on systems of need and fulfillment, which in turn are tied to humans' ways of life. Consequently, it is the human context that determines whether something is considered technology or not. In this regard, Val Dusek (2007) cites an interesting case in which non-western technology was displayed merely as aesthetic or artistic objects in an exhibit at the Museum of Modern Art: "Indigenous implements and twentieth-century Western abstract art objects were exhibited side by side to emphasize the similarity of shape

and design" (Dusek 2007, 33), without explaining the use of the primitive implements. Thus, while the artifacts were both technology and art for their original users, museum visitors regarded them solely as art. Therefore, it makes sense that a technological artifact, when placed in a new context, can lose its identity as a piece of technology and be understood to be something totally different.

The ideas of the autonomy of technology and technological determinism have also been criticized by theorists of the second generation. Their main strategy for challenging these ideas is to propose case studies that illustrate how social, political, and economic factors influence the development, acceptance, and pervasiveness of technologies. Wiebe Bijker's study of bicycle development is an illuminating example in this regard. Bijker (1997) shows via historical investigation that there were various paths for the development of bicycles, and the current standard configuration (with equal wheel sizes) is the result of social competition. Therefore, the design and development of technologies are affected by social preferences. But If non-technological factors, like social preferences, play a role in technological transformations, it is evident that the idea of the autonomy of technology faces a counter-example. Also, if some technical artifacts (like non-standard bicycles) do not receive pervasive acceptance among society, it is unlikely that such things can necessarily lead to substantial social changes; consequently, the strong version of technological determinism would seem untenable.

From what has been said above, it is clear that philosophers of technology have adopted a wholly different approach since the empirical turn. The differences between classical and empirically-informed philosophies of technology can be articulated in eight categories. First, while classical philosophers of technology focused mainly on transcendental questions about technology, second-generation philosophers broadened the kinds of questions they asked. Second, unlike classical philosophers, second-generation thinkers were generally neutral regarding technology. Instead of expressing absolute optimism or pessimism about technological development, they sought primarily to understand it. Therefore, as the third difference, their philosophies were generally descriptive rather than normative. Fourth, second-generation philosophers paid serious attention to different technologies in different contexts instead of talking about 'Technology' with a capital T. Fifth, in contrast to classical philosophers' abstract confrontation with Technology, second-generation philosophers tried to examine technologies in a concrete way using empirical case studies. Sixth, while classical philosophers believed in the essence of technology, the next generation adopted an anti-essentialist stance. Seventh, the idea of technological autonomy, which was popular among classical philosophers, was severely contested after the empirical turn. Eighth, classical philosophers believed in a strong version of technological determinism, but second-generation thinkers replaced this idea with a moderate version.

4 Third Generation: Moralizing Technical Artifacts

The empirical turn introduced a novel approach to the study of technology and started a new field of study where many aspects of the complex mutual relationship between technology and human beings were investigated. The influence

of the empirical turn still remains, and the project of developing empirically-informed philosophy regarding technology is currently being continued by third-generation philosophers of technology.

Despite the fact that the current researchers are generally influenced by the same empirical turn, there is a significant characteristic in their works that distinguishes them philosophically from the second-generation philosophers. This characteristic is the rehabilitation of normative concerns. Kroes and Meijers (2016) and Verbeek (2010, 162) refer to this transformation as "the axiological turn" and "the moral turn" (in the philosophy of technology), respectively.

To better understand the idea of moralizing technology, the most essential and distinctive project of the third generation of philosophers of technology, it's important to note two crucial points. The first thing to keep in mind is that the idea of moralizing technology is regarded as a *reformist* project. Though third-generation philosophers of technology share the first-generation's normative attitude, they do not take a negative approach toward technology. Unlike classical philosophers, they do not wishfully expect a world-historical transformation in which human beings can cross technology. Rather, they believe in the endowments of technology. Nonetheless, they aim to mitigate the undesirable effects of technology through technological practices (Grunwald 1999, 6; Brey, 2017, 6). According to their point of view, technology and technological practices might be a source of the problem, but they may also be the solution. As a result, instead of rebelling against technology, accompanying technical artifacts to the desired destination is on their agenda (Verbeek 2011, 153). Second, these philosophers do not follow their ethical concerns towards technology in an external way. To them, it is not desirable that designers and engineers develop technical artifacts without considering ethical considerations, and only after technology has become prevalent in society do ethicists—as the guardians of humanity— evaluate such products from a moral standpoint and say 'Yes' or 'No' to them. They follow an internal approach according to which ethical considerations are not "end-of-pipe measures" (Brey, 2017, 3), but rather should be considered from the earliest stages of technology development, the design process. These philosophers argue that since technological artifacts can take shape in human decisions and actions and have profound social consequences, engineers and designers have a moral obligation to take moral considerations seriously in their work so that their products do not contribute to the violation of ethical norms. Verbeek writes on these points:

> Accompanying technological developments requires engagement with designers and users, identifying points of application for moral reflection, and anticipating the social impact of technologies-in-design. Rather than placing itself outside the realm of technology, ethics of accompaniment will engage directly with technological developments and their social embedding. (Verbeek 2011, 164)

Therefore, it is of utmost importance in such an approach to design technical artifacts in such a way that these products embody and reflect certain social and moral values, or at least do not violate them.

5 The Insufficiency of Small Efforts

The idea of moralizing technical artifacts through the design process is a thesis that paves the way for addressing some ethical issues with technology. Ethicists working within the Value-Sensitive Design (VSD)[1] framework, for instance, have done several projects aimed at redesigning some technologies in order to better protect values like privacy and human dignity. Nonetheless, this approach, as Mitcham points out, has not been successful in dealing with *large-scale* socio-ethical problems in the technological world. Based on scientific data, issues such as ecological crises and their manifestations like global warming, climate change, water stress, and air pollution have been deteriorating during recent decades. Considering this fact, Mitcham speaks of "the impotence of [these] small efforts" (2020, 594) and suggests an alternative approach according to which philosophers should rehabilitate *big* themes and ideas from the classical philosophy of technology once again.

Those who support the current approach may object to Mitcham's point, arguing that he has drawn a hasty conclusion: the lack of success of the current approach today does not necessarily imply its inability to succeed in the future. They may claim that if these, so to speak, small efforts aggregate in the long run, something big in response to ecological crises will eventually be achieved. From this perspective, step-by-step efforts in inventing new technologies to mitigate the negative effects of other technologies and redesigning current technologies to improve their environmental efficiency may be an arduous and time-consuming project, but it is ultimately rewarding; therefore, the outlook for the current approach is not at all bleak.

Mitcham himself did not take this potential counterargument into consideration. Nonetheless, we contend that one may still hold to Mitcham's general point with slight modifications. We do not deny that the current approach to the ethics of technology may be fruitful in dealing with some large-scale problems. In our opinion, technological development as well as technological practices are part of a comprehensive solution to addressing large-scale socio-ethical issues. However, we believe that the current approach should be supplemented, though not supplanted, by other approaches. As a result, instead of arguing in favor of the 'impotence' of small efforts, we prefer to talk about the 'insufficiency' or 'inadequacy' of this approach.

As mentioned briefly before, the current approach posits that socio-ethical problems in technological development arise mainly due to *technological ambivalence*—the fact that technologies, particularly emerging ones, can have unexpected or unwanted consequences. The current approach suggests two steps to deal with this issue. First, developers should anticipate the socio-ethical consequences of their future products or carefully scrutinize available technologies in various contexts to understand their potential side effects. Second, designers and engineers should use technological practices to eliminate or at least minimize negative consequences. Consequently, this approach seeks to address the moral challenges of technologies

[1] For more studies, see Davis & Nathan (2015)

through technological practices, with engineers and designers serving as "moral heroes" (Alpern, 1983).

However, it seems that, so to speak, the socio-ethical opacity or ambivalence of technology is not always the main source of problems, nor are technical experts the most influential players in overcoming the challenges. This is because it seems plausible to think that at least some of the large-scale challenges that humanity faces today have political as well as cultural roots and are related to the conceptions and expectations that human beings have of the world, their ideals of life, and the way they encounter reality. As a result, there may be viewpoints arguing that, in order to overcome contemporary crises, changes must be made in areas such as human beings' ways of life, governance models, or even fundamental beliefs.

To be more specific, let us briefly explain some of these viewpoints that highlight the importance of political, cultural, and fundamental elements, respectively, in addressing large-scale challenges. It is important to note that we do not wish to argue in favor of these approaches in this paper. Rather, we just want to explain some other points of view that, prima facie at least, seem plausible so that one can think more about them as alternatives to the current purely technocratic approach.

The first possible approach highlights the role of decision-makers, politicians, high-ranking officials, and general governance models rather than designers, engineers, and technological practices in addressing large-scale problems like global warming. As accurately stated by Grunwald:

> [S]haping future technology is done only partly by engineers. Political institutions formulate limits for technology, they are steering technology indirectly by taxes, they are setting negative selective filters for technology development, or they give direct incentives to certain developments by R&D promotion programmes. (Grunwald 1999, 181)

For example, advocates of this viewpoint may argue that all experts agree that the reliance of industries on fossil fuels has negative effects on the environment and causes global warming, which harms all humans, regardless of where they live. Moreover, experts agree on what should be done to fix or at least mitigate this problem, such as investing in renewable sources of energy and reforming industrial models. But what is lacking is the *political will* to implement such solutions. When it comes to governance, it seems that some decision-makers and politicians prioritize economic growth and reducing the unemployment rate over ecological concerns. As a result, although being well aware of the negative environmental effects of their decisions, political forces refuse to agree to cease some industrial activities, which may lead to unemployment. When taking all of this into account, it becomes clear that a transformation in the governance paradigm, including a revision in priorities, is necessary to effectively address ecological problems of this kind.

Others may argue that one of the main causes of environmental crises is the *modern lifestyle* and economic model behind it. This viewpoint holds that the ideals of consumerism and capitalist thinking, which encourage people to consume more and more, have imposed an additional burden on natural resources, resulting in a significant disruption of the ecological balance. Therefore, they may suggest that a transformation in human lifestyles, like reforming consumption patterns through

educational and cultural activities, as well as a complete revision in the core institutions of modern life, like capitalist metrics of progress such as unlimited economic growth (Brey, 2017, 5), are necessary to address these challenges. In this regard, Nasr says:

> There are technologies which can reduce pollution, but I do not believe that those technologies alone will save us from this crisis. We have to have an inner transformation. We have to have another way of looking at ourselves, at what the purpose of human life is, at what satisfies us, what makes us happy, and not turn over to consumption as the only way to be happy, seeking satiation of our never-ending thirst and satisfaction of endless wants that are then turned into needs (Nasr & Iqbal 2009, 129).

As a third way of looking at the problem, one could argue, on a more *fundamental* and *abstract* level, that the major source of ecological issues is how humans encounter reality. According to this viewpoint, in the modern outlook, there is a sharp distinction between subject and object, so that a human being finds herself confronting the world surrounding her. In such an attitude, nature is seen as something external that must be conquered; as a result, humans, as Bacon suggests, employ their will to power in order to dominate the world. However, some traditionalists who draw their inspiration from spiritual religions and indigenous philosophies (Nasr, 1996) have argued that saving the earth requires a change in humans' fundamental perspective so that they can once again cordially embrace the world. In such a way of encountering reality, humankind does not conceive of nature as an alien object out there waiting to be conquered. Rather, they see nature as a sacred mother who, while kindly feeding human beings, has her own rights and should be respected and protected by her sons and daughters.

Given the prima facie plausibility of the aforementioned approaches, it is possible that technocratic treatments alone are not sufficient to address large-scale ethical crises in the technological world. Hence, an important question arises: why has the current approach to technology ethics solely emphasized technological roots and solutions, disregarding the crucial role that cultural, political, and fundamental elements might play in addressing these challenges?

We think that the extreme adherence to the methodological doctrines of the empirical turn is the main reason why third-generation philosophers do not pay serious attention to such non-technological aspects. As previously explained, the classical philosophers were accused of 'ivory tower philosophizing' by proponents of the empirical turn, meaning that their claims and considerations regarding technology are general, abstract, and lacking empirical accuracy. In response to such a circumstance, empirical turn proponents suggest that philosophers should get out of their armchairs and closely examine technical artifacts and technological practices. However, this, so-to-speak, microscopic approach to technology has its disadvantages. From a phenomenological point of view, while the microscopic view enables us to see important details of the issue at hand, it also restricts our vision to a limited scope, preventing us from considering other important aspects in the bigger picture. Taking this into account, it can be argued that even though the empirical turn has illuminated many aspects of the human

relationship with particular technical artifacts in specific contexts, it has also constrained our scope of investigation to the extent that certain crucial normative questions pertaining to technology development, which contribute to the 'macro-ethics of technologies', are not considered seriously.

Unlike the current approach, which can be called the '*micro*-ethics of technology', the macro-ethics of technology does not confine its concerns to particular artifacts in a specific context. It does not study technical artifacts in isolation, but rather broadens its perspective to see the relationships among technical artifacts as a whole. It then places this whole—the technology system or array—in a broader context so that the relationships between political, social, cultural, and fundamental elements of the technology system can be considered. In other words, whereas the micro-ethics of technology has an atomistic and particularistic attitude toward technical artifacts, where properties like design or efficiency are important, *the macro-ethics of technology proposes a holistic and generalist approach to technologies in which the relationships among technical artifacts and the technology system as a whole are significant*. As we will see in more detail, this approach paves the way for proposing questions whose answers may play a role in facing large-scale challenges.

Let's use the example of a car to illustrate the points mentioned above and introduce the types of questions that arise in the macro-ethics of technology. Although a car is made up of many components, one can focus on particular components, such as its wheels and tires, and evaluate their designs and performance in different situations. However, one can also take a broader perspective and examine the car as a system, looking at how its different components work together. For instance, one can consider the fact that the wheels' movements depend on the axles and how these components work together within a larger system to form a working car. One can also ask various normative and evaluative questions, such as whether the car's performance is optimal, whether the fuel source or driving force is appropriate, who the driver is and if they are qualified enough to transport passengers to their destination, and so on.

Similarly, a holistic approach is available in the ethics of technology, which examines the relationships among different technical artifacts within a technology system as a whole and poses critical questions about this system. A holistic perspective, as opposed to an atomistic view that focuses on *individual* technical artifacts in *specific* contexts and considers their values and potential negative effects, asks fundamental questions about the system as a *whole*. Some examples of such questions are: is the current technology system optimal? How far is it from the ideal configuration? What kind of lifestyle is proportional to this system? From what system of needs and satisfaction does it originate? What is this system's driving force? What purpose is it serving? What future does it envision? Who are the drivers? Who should be the drivers? Moreover, one can ask about the social and political structures that better fit this technology system, as well as whether each structure should have its own technology system. One can also consider whether the governance models of these systems are value-laden or not. By posing these broader and more in-depth questions, she can develop a better understanding of the macro-ethics of technology and address significant challenges in her relationship with technology. Therefore, this

approach enables us to consider the broader implications of technology on society, including issues such as governance, sustainability, and social structures.

6 The Holistic Approach to the Ethics of Technology

According to our interpretation, when Mitcham argues in favor of a transformation in the ethics of technology, he suggests that researchers should turn to the macro-ethics of technology in order to address contemporary challenges. For example, in the abstract of his paper, he writes:

> The trajectory of critical ethical reflection on technology has been from big issues (eighteenth century arguments for social revolution responding to the evils of the industrial revolution) to small ones (particular issues associated with the practices of engineers). It is time to think in large-scale terms (Mitcham 2020, 589).

Though we agree with Mitcham's general idea about turning to the macro-ethics of technology, we believe that his suggestion is not without shortcomings. The main issue with Mitcham's proposal is that he views the macro-ethics of technology through the lens of the classical philosophy of technology. To put it differently, considering Mitcham's emphasis on the works of classical philosophers, it seems that he wants to rehabilitate the classical philosophy of technology so that we can think big about technology once "again" (Mitcham 2020, 589). At the very least, his work is ambiguous as to whether he intends to entirely return to the classical philosophy of technology or to revise themes and ideas from classical works and present them in a new style.

There are indeed important clues in the classical philosophy of technology for engaging with macro-ethical questions; yet, a complete rehabilitation of that way of thinking about technology is untenable. First, considering the empirically-informed philosophy's objections against essentialism, technological determinism, and the autonomy of technology, no one has a good reason for maintaining such ideas. Moreover, the idea of moralizing technology—whether at a micro or macro level—presupposes a belief in humankind's ability to intervene to reform things for a better future, and this belief is incompatible with the absolute *pessimistic* and *passive* approach that classical philosophy takes towards technology. Hence, it is not feasible to suggest the macro-ethics of technology within the conceptual framework of classical philosophy. So, if someone wants to sympathize with Mitcham's general point, it would be better for them to suggest a different way to look at some aspects of classical philosophy. In what follows, we take this sympathetic step. The result of this is the general outline of a new approach to the ethics of technology, which we call the 'holistic' approach.

To take the above-mentioned step and at the same time present the holistic approach in a structured way, we will begin by highlighting key features of the classical approach that should be rehabilitated, albeit under a different interpretation. Next, we will identify those main parts of the classical approach that have no place in our positive proposal because of what we know from empirical findings.

Finally, we will finish this section by shedding light on some of the remaining aspects of the proposed approach that we have been developing.

To make the rest of this section simpler to follow, it is good to list the most important points and claims that the following paragraphs will focus on:

(1) The holistic approach acknowledges Technology (with a capital T), but reinterprets it differently from classical philosophers, who viewed it as an abstract, world-historical phenomenon.
(2) Scientific techniques like 'tech-mining' can be employed to operationalize and analyze the 'technology system' as the new interpretation of Technology.
(3) The holistic approach keeps a transcendental focus, but, unlike the classical approach, it extends its inquiries beyond the mere conditions of possibility for technology: it encompasses a broader range of concerns.
(4) Both classical and holistic approaches adopt a normative attitude towards technology, but the holistic one is not pessimistic: it adopts a realistic stance toward technology and technological development.
(5) The holistic approach actively avoids passivity in the face of technology, aligning with the macro-level project of moralizing technology.

As previously stated, one of the main characteristics of the classical philosophy of technology is thinking about Technology with a capital T. Based on our attitude in this study, we offer an alternative interpretation of this feature that, we believe, presents a new perspective on the ethics of technology. By reviving 'thinking about Technology with a capital T,' we do not intend to return to an abstract and general attitude toward technology, ignoring crucial differences among various technologies that lead to monolithic descriptions and judgments. Rather, by talking about Technology, we insist that researchers should take a *holistic* look at the relationships among technologies and consider the technology system as a whole. In other words, in this alternative interpretation, 'Technology' is nothing but *the network of technologies interconnected as a whole*.

It is important to note that the technology system is *not* an abstract and imaginary entity. Rather, it can be operationalized and evaluated by employing methods such as those offered within the field of science known as *tech-mining*. Tech-mining is a research area that analyzes vast collections of scientific, industrial, governmental, and technical data using data mining, machine learning, and natural language processing techniques. This analysis enables researchers to identify the important technologies and their relationships in terms of a dynamic graph with nodes representing technologies and edges representing relationships among them, which can inform strategic decision-making, innovation, and technology management (Porter & Cunninghum, 2004). Using tech-mining methods, researchers can map a network of technologies and raise and answer certain significant normative and evaluative questions regarding its governance, some of which have a substantial ethical nature. For example, it can be asked whether the current technology system is optimal so that it can bring about the good life for human society, and if not, how technology policy-makers might attain a better

configuration. Furthermore, one may ask questions regarding who benefits from the current technology system, who is left behind, and, in general how the technology system relates to the ideals of justice and equality. Additionally, questions regarding the drivers and leaders of the technology system have some normative potential.

To be more specific, one way that tech-mining might address moral concerns is by tackling the challenging task of allocating financial resources to different parts of a government's technology system. Such choices are always value-laden and reflect the priorities of the governing model. For instance, in a capitalist governance model, investment cost optimization often becomes the decisive factor in selecting industrial project portfolios and determining investment priorities. Nevertheless, relying merely on cost optimization might not be the best approach. There are several other metrics that might play a key part in selecting and shaping the portfolio, such as reducing unemployment rates, waste reduction, improving the GDP index, or lowering carbon dioxide emissions. Even by optimally combining various metrics, it is possible to arrive at the most effective configuration of the technology system that contributes to the overall ethical ideals and happiness at the macro-level. To give a more tangible illustration, a group of researchers has employed tech-mining methods and mathematical calculations to develop a model for selecting an industrial portfolio and determining portfolio priority for investment (Azimi et al 2019). Their methodology appears to allow policy-makers to consider multiple factors beyond just cost optimization when making decisions about technology investments, even though their focus was on investment cost optimization. It is important to note that this suggestion is only preliminary and needs further development.[2] However, our scholarly guess is that tech-mining could be a beneficial framework and method for developing a more morally responsible technology system. We can achieve greater social benefits and contribute to a more equitable and sustainable society if we incorporate ethical considerations into the design and implementation of technological systems.

Due to the critical role that tech-mining can play in putting the new perspective on Technology into reality, it may be beneficial to provide an overview of the above-mentioned methodology and how it can contribute to the macro-ethics of technology.[3] As stated above, one of the most significant concerns in technology macro-ethics is how we may reach or come close to an ethically ideal configuration of a technology system. In practical terms, this translates to determining how development plans should prioritize technological projects and allocate financial resources to ensure the technology system aligns with the ideal of morality, promoting a good

[2] While the aim of this paper is to shift focus to the macro-ethics of technology and propose a new approach in this field, further research programs are required to identify challenges and assess the consequences of putting such an approach into practice.

[3] A detailed description of such methodology, which has connections to other fields such as graph theory and computer science, is beyond the scope of this philosophy work. We will therefore only mention the main steps in a general and non-technical language.

life.[4] To use the suggested methodology (Azimi et al. 2019) to address this macro-ethical question, one should first reach the technology system in terms of a weighted dynamic graph, which may be called a tech-graph. The tech-graph is built through two recognized steps in tech-mining: (1) identifying technologies using a text mining method called 'Technology Term Recognition (TTR)'; and (2) using Association Mining (AM) to find the relations among them. It is crucial to note that the tech-graph goes beyond simply presenting technologies and their relationships; it also includes the weight of technologies in the network as well as the direction of associations among them. Essentially, the tech-graph reveals the dependency of technologies by highlighting 'centralities', which represent focal technologies that should receive investment for the advancement of a branch of technologies in the technology system. With the tech-graph in hand, the next step is to prioritize among centralities by introducing a function into the graph's mathematical equations. It is clear that each prioritization, derived from adding a desired function, leads to a different configuration of the technology system over a long period. Meanwhile, it is important to consider that the prioritization is the result of a wholly value-laden decision tied to the governance model's basic concerns. Depending on whether the main concern is optimizing investment costs or addressing issues such as controlling Earth's temperature, the prioritization of centralities and consequently the technology configuration would vary.[5] Besides investment cost optimization and climate control, there are various other ethically and ecologically desired metrics that could be added to the graph. For example, eliminating greenhouse gas emissions, fostering economic growth, reducing unemployment rates, lowering carbon dioxide emissions, and minimizing waste reduction are all metrics that could likely be translated mathematically into a function that could be added to the tech-graph in order to reveal the prioritization in macro-development plans. Importantly, it should be noted that a combination of these functions can be added to the tech-graph, resulting in an ethically ideal technology system configuration that not only promotes economic growth but also addresses waste reduction, unemployment rates, carbon dioxide emissions, and other desired metrics simultaneously.

Having finished discussing tech-mining's potential contribution to our proposed holistic view of technology, let us keep looking at the elements of classical philosophy and how they are treated in this proposed view. Another aspect of classical philosophy that somehow has a place in our proposed approach is the transcendental style of thinking about technology. In our view, questions concerning the preconditions for technology development, including the social and political infrastructures, and cultural and fundamental elements that make technologies and the technology system possible, should be raised and explored once again. These questions put the technology system in a broader context and

[4] These macro-ethical issues are rarely addressed in the current dominant approach to technology ethics, which primarily focuses on *micro*-ethical concerns. Rather than aiming to guide Technology towards ethically ideal destinations, the emphasis is on moralizing technical artifacts. The legitimacy and significance of such concerns, in our opinion, are compelling grounds to see the current approach as 'insufficient'.

[5] For example, when a country joins the Paris Climate Agreement, it should adjust its technology system configuration in order to meet its commitment to tackle rising earth temperatures.

highlight elements such as modern lifestyle, the consumerist system of needs and satisfactions, and capitalist leanings in the political structures on which modern technology relies. As a result, the macro-ethicist of technology may better assess whether these infrastructures and elements contribute to contemporary crises and how changes in these issues may pave the way for overcoming the challenges.

Nonetheless, it should be emphasized that the new approach being proposed does not restrict itself, unlike classical philosophy, only to transcendental questions regarding technology and technology development. For, while it considers the systems of needs and desires from which specific systems of technologies have developed, it also tries to predict the future lifestyles that these systems of technologies will produce. Therefore, in addition to backward thinking about technology, the proposed approach also includes forward thinking, looking to the potential future of the social, cultural, and political impacts that technology would likely lead to. In other words, this alternative approach aggregates between retrospective and prospective outlooks regarding technology development.

The normative attitude toward technology is another classical characteristic that should be preserved in the new approach. However, it should be emphasized that rather than adopting a merely pessimistic or overly optimistic attitude towards technology, ethicists should take a realistic approach and make suggestions to accompany not only technical artifacts but also the technology network as well as the social, cultural, political, and economic infrastructures of technology development towards the morally desired destination.

Despite some similarities between the proposed approach and classical philosophy, certain classical characteristics have no place in the macro-ethics of technology. It is obvious that the proposed approach believes in the dependence of technology systems on social, political, cultural, and economic structures. Additionally, it implies that adjustments to such structures, such as adjustments to consumption patterns or governance models, can accompany the network of technology toward a better status, thereby enhancing human well-being. Moreover, this approach assumes that human intervention, like proposing creative ideas and practices that affect the nodes and edges, can improve the aforementioned graph. Therefore, *our proposed approach agrees with the findings of empirical studies conducted by the second and third generations of philosophers,* which suggest that the idea of technology's autonomy or of passivity in the face of technology is unfounded. In our view, the complexity of issues regarding technology development, such as the existence of an invisible network of capitalist power that directs the technology system to its own benefits, should not lead people to believe that technology is an independent, pervasive power against which they have no control.

Permit us to finish this section by shedding light on and clarifying some further aspects of the proposed approach (the holistic approach) that we have been developing. To begin with, the holistic approach focuses on the central issues of time rather than marginal and minor ones. Indeed, it puts the devastating, large-scale challenges of the contemporary world, such as ecological crises, at the center of its deliberations. To put the same idea differently, while micro-ethicists of technology investigate how a particular technical artifact has caused a moral issue in a specific context,

macro-ethicists do not think locally but globally, engaging with the possible causes and solutions of pervasive crises, like global warming, that threaten humankind.

Moreover, the holistic approach does not lose sight of the big picture. At the same time, it does not lose sight of the important details of the technological realm. As discussed before, this approach takes a holistic view of the technology system, considering the broader societal context in which technology is embedded. In addition, while it considers the technology system as a whole, it does not ignore the role of specific technologies, especially disruptive ones, in the configuration of the network. In other words, when considering Technology with a capital T, it is not the case that researchers ignore the technologies with a small t, since the relationships among technologies, whether they are emerging or established, play an essential role in the constitution of the whole. In fact, it is the interconnections of technologies that constitute Technology. As a result, the new approach to the ethics of technology finds itself aggregating between the apparently divergent ways of emphasizing *Technology* (capital T) and *technologies* (small t).

Furthermore, the suggested approach has a self-critical attitude, in the sense that it has the potential to develop the idea that, in order to overcome the devastating challenges of the technology world and save the planet for future generations, people must first change themselves. To be more specific, while the first and third generations of philosophers blame technology itself for morally significant challenges by, respectively, depicting it as an autonomous power and highlighting its socio-ethical opacity, the preferred holistic approach may come to the conclusion that it is humans' consumerist lifestyle or the way they engage with reality that causes the problems. As a result, in this approach, the users of technology are considered key players in both generating and solving problems.

Finally, our proposed approach puts the large-scale socio-ethical problems of the technological world in a broader context, trying to find their roots at different levels, including social, political, cultural, and fundamental ones. As a result, when it comes to offering solutions, unlike the third-generation philosophers who restrict their solutions to technocratic ones and put the responsibility of moralizing technologies solely on designers and engineers, this approach takes an all-encompassing and more realistic stance, emphasizing the role of policymakers, politicians, and users in solving the problems.

7 Conclusion

In this study, our objective was to make a contribution to Mitcham's big idea. Through our efforts, we have proposed a new approach to the ethics of technology, which we call the 'holistic' approach. This new way of thinking about technology is a synthesis of ideas from three different periods in the philosophy of technology. While we agree that the micro-ethics of technology has the potential to address some of the socio-ethical challenges raised by technology, we maintain that macro-level considerations are also necessary for a comprehensive understanding and treatment of the issues that come with technology. Indeed, integrating micro and macro levels is essential if we want to steer the technological world into its maturity in a

way that is sustainable, equitable, and beneficial for all. Our proposed macro-ethical approach allows researchers to ask important yet often overlooked questions about technology, leading to more comprehensive solutions for the crises that afflict our technological world. Compared to current approaches to the ethics of technology, our proposal offers several advantages. Firstly, it provides a more comprehensive approach to addressing ecological crises by considering all potential sources of the problem. Secondly, it does not just use a technocratic approach; it recognizes that various players, such as users, politicians, and policymakers, may all have important parts to play in finding solutions.

Author contributions Since a significant portion of this article's content and research is derived from the master's thesis written by MSJ and supervised by JAT (at Sharif University of Technology), and because MS and J, respectively, played an important role in the article's subsequent development, it can be stated that the article's main contribution belongs to these two individuals. But because a third person—MF, who is designated as the paper's second author in the list of authors—participated in the subsequent advancement of the article, especially in its ending section (Sect. 6), a portion of the article's contribution also goes to him.

Funding This research has not received any funding from any source.

Declarations

Conflict of interest This is a research article written primarily for the authors' academic status and career, not for any special financial or other non-financial interests.

Ethical Approval The authors attest that the submission adheres to all of the journal's ethical guidelines.

References

Achterhuis H (2001) American philosophy of technology. Indiana University Press
Azimi S, Rahmani R, Fateh-rad M (2019) Investment cost optimization for industrial project portfolios using technology mining. Technol Forecast Soc Chang 138:243–253
Bijker WE (1997) Of bicycles, bakelites, and bulbs: toward a theory of sociotechnical change. Mit Press
Brey P (2010) Philosophy of technology after the empirical turn. Tech: Res Philos Technol 14(1):36–48
Brey P (2017) Sustainable technologies for sustainable lifestyles. In: Kaplan D (ed) philosophy, technology and the environment. MIT Press
Briggle A (2016) The policy turn in the philosophy of technology. Philosophy of technology after the empirical turn, 167–175.
Davis J, Nathan LP (2015) Value sensitive design: applications, adaptations, and critiques. In: van den Hoven J, Vermaas P, van de Poel I (eds) Handbook of ethics, values, and technological design. Springer, Dordrecht
Dusek V (2007) Philosophy of technology: an introduction. Blackwell
Ellul J (1967) The technological society. Vintage Books
Feenberg A (2000) From essentialism to constructivism. In technology and the good life? 294–315
Franssen M, Vermaas PE, Kroes P, Meijers AWM (2016) Editorial introduction: putting the empirical turn into perspective. In: Franssen M, Vermaas P, Kroes P, Meijers A (eds) Philosophy of technology after the empirical turn. Philosophy of Engineering and Technology, vol 23. Springer
Grunwald A (1999) Technology assessment or ethics of technology? Eth Perspect 6(2):170–182
Heidegger M (1969) Discourse on thinking (J. M. Anderson, Trans.). Harper & Row
Heidegger M (1977) The question concerning technology. Harpercollins Publishers, New York

Jaspers K (1965) The origin and goal of history (M. Bullock, Trans). Yale University Press
Kroes P, Meijers AWM (2016). Toward an axiological turn in the philosophy of technology. In philosophy of technology after the empirical turn, 11–30.
Kuhn TS (1962) The structure of scientific revolutions. University of Chicago Press
MacKenzie D (1984) Marx and the machine. Technol Cult 25(3):473
Marcuse H (1968) One dimensional man: the ideology of industrial society. Sphere Books
Mitcham C (1994) Thinking through technology: the path between engineering and philosophy. University of Chicago Press
Mitcham C (2020) The ethics of technology: from thinking big to small—and big again. Axiomathes 30(6):589–596
Naṣr SḤ (1996) Religion and the order of Nature; the 1994 cadbury lectures at the University of Birmingham. Oxford University Press
Nasr SH, Iqbal M (2009) Islam, Science, Muslims and technology: Seyyed Hossein Nasr in conversation with Muzaffar Iqbal. Dost Publications
Porter AL, Cunningham SW (2004) Tech mining: exploiting new technologies for competitive advantage. Willey
Verbeek PP (2005) What things do: philosophical reflections on technology, agency, and design. Pennsylvania State University Press
Verbeek PP (2011) Moralizing technology: understanding and designing the morality of things. University Of Chicago Press
Vermaas P, Kroes P, Van De Poel I, Franssen M, Houkes W (2011) A philosophy of technology: from technical artefacts to sociotechnical systems. Springer