Chapter 17
The Philosophy of Technology: On Medicine's Technological Enframing

Benjamin Chin-Yee

17.1 Introduction: Questioning Medical Technology

In 2012 IBM,[1] in partnership with Memorial Sloan Kettering Cancer Centre, announced the development of Watson for Oncology, a supercomputing initiative which applied Artificial Intelligence (AI) to solve one of modern medicine's biggest challenges: how to effectively treat patients with cancer. Watson for Oncology, marketed as a clinical decision-support system, analyses Big Data—from medical records, pathology and imaging reports to the vast research literature and clinical practice guidelines—to recommend the 'best', personalized treatment for a given patient. Following this announcement, IBM formed partnerships with major cancer centres and health systems around the world in pursuit of its goal to revolutionize cancer care. Ultimately, however, Watson for Oncology did not achieve its aim, facing mounting criticisms over inaccurate recommendations, lack of sensitivity to local context, and overreliance on opinion of American experts (Tupasela and Di Nucci 2020). Yet despite these criticisms, as well as an ongoing paucity of evidence that the tool improves patient care, the project was an integral part of IBM's Watson Health division (2022).[2]

Over the past decade, enthusiasm for AI in medicine has only grown, and AI's ability to offer technological solutions for a wide array of clinical problems now seems boundless. Watson for Oncology is just one high profile example amongst a myriad of AI applications in healthcare, which range from interpretation of diagnostic

[1] International Business Machines Corporation, an American multinational technology corporation.

B. Chin-Yee (✉)
Division of Hematology, Schulich School of Medicine and Dentistry, Western University, London, ON, Canada
e-mail: benjamin.chin-yee@lhsc.on.ca

Rotman Institute of Philosophy, Western University, London, ON, Canada

[2] Since the time of writing, IBM has sold its Watson Health data and analytics business.

M. E. L. Brown et al. (eds.), *Applied Philosophy for Health Professions Education*,
https://doi.org/10.1007/978-981-19-1512-3_17

testing to prediction of clinical outcomes and treatment recommendation (Topol 2019). Exuberance for medical AI has been met with concerns over epistemic and ethical problems posed by these technologies (Chin-Yee and Upshur 2019), including issues of bias, transparency, accountability, and trust, which link to more general debates in the ethics of AI (for examples, see Dubber et al. 2020) Engagement with these philosophical issues is of increasing relevance in health professions education, which must continually adapt to medicine's rapidly evolving technological landscape and reckon with the resulting impact on clinical training and professional identities.

This chapter raises a more fundamental philosophical question prompted by these recent trends: to what extent are the problems of medicine—that is, the problems that we train clinicians to address in practice—amenable to technological solutions? Put differently, how did medicine arrive at a point where clinical judgment, once a paragon of human reasoning, became something that might be best performed by a machine? While such questions are not new—indeed, critiques of biomedicine's 'technological imperative' are longstanding (for example, see Burger-Lux and Heaney 1986)—recent developments in Big Data and AI give new impetus to address these questions and revisit the role of technology in medicine today. To this end, this chapter undertakes a foray into the philosophy of technology to extract relevant insights for health professions education.

I begin by discussing the relationship between science and technology and introduce the commonplace positivist view of technology prevalent within the medical profession. This is followed by a selective survey of approaches in the philosophy of technology, focusing on critical accounts by three philosophers from distinct periods and intellectual traditions, Martin Heidegger (1889–1976), Andrew Feenberg (1943), and John Dewey (1859–1952). I highlight how these philosophers challenge received views on the place of technology in modern society and offer particularly relevant insights for questioning medical technologies. This discussion emphasizes three key themes for health professions education while dispelling three myths of the positivist position: first, technology does not simply refer to material artifacts but describes a particular way of thinking and interacting with the world; second, technology is not value-neutral but rather reflects a range of social choices and human values; and third, technology does not serve as pure means to fixed ends but instead exists as a continuum of evolving means and ends. By introducing readers to key issues in the philosophy of technology, my aim is to support reflection and critical engagement amongst clinicians, educators, researchers, and trainees with the technologies that increasingly play a pivotal role in clinical practice.

17.2 Art, Science, or Technology?

Is medicine an art or a science? This oft-repeated false dichotomy, while debunked by a number of scholars (for examples, see Montgomery 2005; Whitehead and Kuper 2015; Fuller 2015; Solomon 2015), seems to hold continued traction amongst students and healthcare professionals today. Perhaps this is because it gives expression to a particular uneasiness with medicine's irreducible uncertainties felt especially amongst healthcare professionals whose training disproportionately focuses on medical 'science', where 'science' continues to be understood in narrow, positivist terms, as the privileged mode of access to value-free facts about the world. Preserving the category of 'art', encompassing and nebulous, ensures that all of medicine's uncertain elements—from intuition and emotion to ethics and values—can be neatly cordoned off from its more 'scientific' base. This perspective still leaves the path open for medical science to gradually work away at these uncertainties, with the hope that the vagaries of 'art' will soon become relics of a bygone era, the stuff of Hippocrates and Osler but not befitting the contemporary clinician equipped with modern science and its technological affordances.

There is a grain of truth in this slightly hyperbolic narrative about scientific medicine. Positivism and foundationalism are alive and well in medicine today (See Chap. 13 for an overview of this state of affairs). One example is provided by the Evidence-Based Medicine movement (for discussion, see Bluhm and Borgerson 2011), which sought to establish clinical epidemiology and its tools as medicine's new 'base'—the new "basic science for clinical medicine" (Sackett 2005). Such views continue to inform more recent data-driven, quantitative approaches, including medical AI, which promise to bring us closer to 'truth' in diagnosis, prediction, and treatment decisions (Chin-Yee and Upshur 2018, 2019). While there is a tendency to classify these developments as advancements in the science of medicine, which remains the emphasis of health professions education, these latest trends also highlight medicine's growing technological dimension. Making sense of these trends and their meaning for the medical profession, therefore, requires that we ask: what is the relationship between medicine's science and its technologies?

According to the received view, the answer is straightforward: technology, simply put, is applied science. Medical technologies, therefore, are the application of medical science. Science teaches us how the immune system functions; vaccines are technologies which leverage that understanding to prevent disease. Science tells us how cells divide and proliferate; cancer therapies are technologies that exploit this knowledge to abrogate the process. What I have just introduced can be termed the positivist view of technology, a commonly held perspective that serves as a foil to the critical approaches discussed below. The positivist view of technology follows from its view of science. By this account, 'pure' science involves the pursuit of theoretical knowledge, which is value-free, ahistorical and universal; technology is the application of this theoretical knowledge towards the efficient attainment of practical ends.

Three features of the positivist view are worth noting here. Firstly, it is hierarchical: science precedes technology, with scientific knowledge forming the basis of technological innovation. Technology develops as a result of advancement in science and its disinterested pursuit of theoretical knowledge. Secondly, while technology is directed at practical ends, these ends are extrinsic to technology itself which exists as 'pure means' to attain predefined ends in the most efficient and rational manner. This view of technology as 'pure means' to an ends is sometimes referred to as naïve or “straight-line” instrumentalism by its critics (Hickman 1990; Winner 1978). By this view, technology is value-neutral: although it aims at practical ends, which may be socially defined according to various interest and values, considerations of design and function are purely technical and scientifically determined. Thirdly, given that technology is a direct extension of science and embodiment of its rationality, the positivist view confers upon technology a certain scientific legitimacy. For the positivist, science is our best, indeed our only, mode of access to true knowledge about the world, and this privileged status transfers to technology, whereby technology offers our best means of attaining practical ends in the world. Sometimes, this latter perspective is referred to as technological solutionism, or simply solutionism for short. That solutionism often follows from positivist views of science and technology is evidenced by how such arguments often emerge from society’s most scientistic sectors, healthcare included. The rise of solutionism in health professions education in particular has recently come under scrutiny (Ajjawi and Eva 2021).

Needless to say, positivism has encountered a multitude of challenges, both in terms of its views of science and technology. On the one hand, its view of science faced significant criticism by post-positivist philosophy of science. Review of these criticisms is beyond the scope of this chapter (for background, see Chap. 13), but a major source came from historians and practice-oriented philosophers of science, who helped dispel the myth of ‘pure’ science by examining the historical and social conditions that influence the production of scientific knowledge. Of relevance to our discussion, such analyses revealed the bidirectional relationship between science and technology, challenging the hierarchy moving from ‘pure’ science to applied technology. To cite just one example from the history of medicine, Louis Pasteur’s research in microbiology, while often rationally reconstructed as ‘basic’ experiments providing proof of a germ theory of disease, were in fact part of a broader research programme that relied upon a state-of-the-art laboratory technology, as well as knowledge gained from applied processes of fermentation in the brewing industry and agriculture (Latour 1993). A plethora of historical and contemporary case studies bring into question the priority of science over technology, to the extent that some scholars now prefer ‘technoscience’ as a more descriptive term for the amalgam that constitutes modern day research (Pickstone 1993). On the other hand, the positivist view of technology, together with its instrumentalist and solutionist perspectives, have been the focus of significant criticism in the philosophy of technology, which I explore in the next section.

17.3 Lessons from the Philosophy of Technology

Philosophy of technology is a growing discipline which has attracted scholars from a number of different intellectual traditions and orientations. While philosophical engagement with technology has its roots in antiquity (for discussion, see Franssen et al. 2009), contemporary philosophy of technology emerged from attempts to reckon with the growing presence and influence of technology in modern society. As the field expanded it became roughly divided between scholars more interested in questions of design and function of technical artifacts in themselves, often from backgrounds in engineering and analytic philosophy of science, and those occupied with the broader social and existential impacts of technology, often from backgrounds in the humanities and social sciences. The latter is sometimes dubbed the "humanities philosophy of technology" to contrast the "analytic philosophy of technology" (Mitcham 1994). Although this division is imperfect, and many philosophers (including Dewey) do not clearly fit within one side, this introduction will focus mainly on scholars from the so-called humanities tradition, who, by addressing the human and social dimensions of technology, offer insights of particular relevance to health professions education. One entry point into this literature can be found in the work of Martin Heidegger, whose *The Question Concerning Technology* ([1954] 1977) serves as a seminal text for the field.

17.3.1 Heidegger's Question Concerning Technology

To understand Heidegger's philosophy of technology we must first situate it within his broader philosophical project. The central question for Heidegger's philosophy is the question of being. His most celebrated work *Being and Time* ([1927] 1996) is a study of the fundamental nature of human existence or "being-in-the-world". Heidegger challenged Western philosophy's dominant interpretation of human existence as 'spectators' perceiving neutral objects in an external world. Rather, according to Heidegger, we find ourselves "thrown" into a world, already interpreted and imbued with meaning and significance. In a sense, being-in-the-world can be understood as practical in its orientation; objects do not appear to us as simply objects, but rather stand "ready-at-hand", situated within our larger projects and goals, with immanent meaning through their embedding within specific interpretive contexts. To give an example, Heidegger writes of how when we perceive a table in a room, what we perceive is not simply a neutral object, extended in space with specific dimensions and properties, but rather *this* particular table, which may be a *table-for-writing*, a *table-for-dining*, and so on. Moreover, our interpretation of this table is not just personal and idiosyncratic but also incorporates broader historical and cultural valence, felt, for example, when we perceive our old student's desk in our grade school English classroom, or the antique harvest table in our family home. In this way, for Heidegger, being encompasses a mode of disclosing the world—a mode of "revealing" it to us in existence.

Heidegger's philosophy of technology follows from this interpretation of being. Technology for Heidegger cannot be understood in narrow, instrumentalist terms, as value-neutral means to an end, but rather constitutes a mode of being—a mode of revealing the world. As mentioned, Heidegger was a critic of Western metaphysics and the resulting outlook of modern science, which objectifies the natural world.

But rather than technology being the product of this scientific worldview, Heidegger reverses the relationship: the misunderstanding of being found in Western philosophy, and by implication in modern science, is a symptom of technology and its mode of revealing. Here Heidegger inverts the positivist view, asserting the ontological priority of technology over science.

What does Heidegger mean when he calls technology "a way of revealing"? Heidegger points out how technology engenders a particular outlook which shapes our being-in-the world. For example, he argues that through the technological outlook of modern mining and forestry we come to view the earth as a source of mineral deposit or the forest as a source of lumber—ordered "cellulose", as he calls it (Heidegger [1954] 1977). Through this way of revealing "everywhere everything is ordered to stand by". Technology brings about an "ordering" of the world where everything is seen as "standing-reserve". Heidegger refers to this as "enframing", through which "the work of modern technology reveals the real as standing-reserve". For Heidegger, enframing is the essence of technology: "The essence of modern technology shows itself in what we call Enframing". Enframing results in a flattening of the immanent meanings revealed by pre-technological being, and in this way threatens the very act of revealing itself. As Heidegger (ibid) writes:

> The coming to presence of technology threatens revealing, threatens it with the possibility that all revealing will be consumed in ordering and that everything will present itself only in the unconcealedness of standing-reserve (33).

Technology's way of revealing, however, is not limited to the natural world, but also threatens to encompass human beings themselves. Herein, for Heidegger (ibid.), lies the real danger:

> As soon as what is unconcealed no longer concerns man even as object, but does so, rather exclusively as standing-reserve, and man in the midst of objectlessness is nothing but the orderer of the standing-reserve, then he comes to the very brink of a precipitous fall; that is, *he comes to the point where he himself will have to be taken as standing-reserve* (emphasis added, 26–27).

Such a claim might seem unsurprising today, in a time when the datafication of day-to-day existence has become fact of life, serving as a reminder of the power of technological enframing from which human beings are not immune. This enframing is also seen in healthcare, where data-driven technologies effect an ordering of human bodies and their data, which 'stand-in-reserve' as inputs into algorithms. A full discussion of Heidegger's philosophy of technology and its applications to healthcare could fill a volume of this size. The key takeaway for our discussion is Heidegger's view of technology as a "way of revealing" that he calls "enframing", which for him captures the "essence of modern technology".

While Heidegger's writings on technology have been influential they are not without criticism. Although some critics characterize him as a Luddite or Romantic, nostalgically clinging to a pre-technological age, his arguments cannot be so easily dismissed. Heidegger ([1954] 1977) recognized that we cannot simply return to a former, pre-technological mode of being but rather argued that we must strive to gain a "free relationship" with technology. Heidegger himself was notoriously obscure about how this might be achieved, and pessimistic about the prospects, (in)famously stating in his last interview with *Der Spiegel* "only a god could save us now" (Heidegger [1966] 2017). For this reason Heidegger is sometimes seen as a technological determinist, attributing to technology an autonomous power to inevitably shape humanity and the social world. Some interpretations of Heidegger attempt to move away from his determinism and its pessimistic conclusions, for example, offering the possibility of keeping touch with revealing through "focal things and practices" (Borgmann 1984, 16), or cultivating a plurality of modes of being which includes the technological (Dreyus and Spinosa 1997). Such approaches find parallels in health professions education, where some have advocated pluralism with respect to medicine's diverse 'ways of knowing' (Chin-Yee et al. 2018; Thomas et al. 2020). I will return to these ideas below but first introduce another philosopher of technology who attempts to overcome certain limitations of Heidegger's account.

17.3.2 Feenberg's Critical Theory of Technology

Andrew Feenberg is a contemporary philosopher of technology who integrates insights from both Heidegger and the Frankfurt School, especially Herbert Marcuse, to develop what he calls his "critical theory of technology" (Feenberg 1991, 2002). While Heidegger remains his starting point for critical reflection on technology, Feenberg challenges the essentialist and determinist interpretations found in Heidegger and other critical theorists, which tend to overstate technology's autonomy and power over the social world. Rather, Feenberg's account not only looks at how technology shapes society but also how society shapes technology. Here he draws on social constructivism, which examines how social norms and interests influence technological design and operation within 'sociotechnical' systems (for discussion, see Bijker et al. 2012).

Feenberg emphasizes the constructivist notion of technological underdetermination, which holds that considerations of function and efficiency alone underdetermine the design of technical artifacts, which necessarily require additional social choices. Feenberg cites a famous example from Langdon Winner's classic essay "Do artifacts have politics?" (Winner 1980), a question which is answered in the affirmative. Winner discusses how the low hanging overpasses of New York's Southern State Parkway reflect deliberate design choices by their architect, Robert Moses, who sought to exclude low-income and racialized groups that relied on buses to access Long Island's beaches. Winner's case study illustrates how a technical artifact, such as a bridge, is not politically neutral but rather can incorporate racist and classist ideologies in its very design. These ideologies, however, become concealed, inscribed as "technical code" during the artifact's production (Feenberg 2010b). "Technical codes" introduce bias, which can be "substantive", a reflection of societal prejudices, or "formal", arising from the very idea of what constitutes a rational, well-functioning system.

Several scholars offer examples of how design choices encode bias in technical systems, from search engines to insurance algorithms (for examples, see Benjamin 2019b; Noble 2018; Eubanks 2018). Medicine is also ripe with examples, with historians and sociologists exposing how what are commonly taken as neutral instruments can incorporate ideologies of race and gender, from the speculum (Sandelowski 2000) and spirometer (Braun 2014), to state-of-the-art predictive algorithms (Benjamin 2019a). While some might see these as extreme examples, it is important to note that all technologies have an inherently normative dimension written in their technical code, which dictates factors such as which users are included/excluded and how a technology operates within a given social order. To again use the example of vaccine design, factors such as appropriate storage conditions, means of transportation, number of doses required and dosing interval, all might have technical and scientific rationale, but they are also normative, shaping how vaccines are 'properly' used, who has access, and who does not.

Bias, therefore, is a basic feature of all technical systems, which one uncovers by interrogating the co-construction of the technological and the social. According to Feenberg, technology does not simply entail, as it does for Heidegger, a "way of revealing" the world as decontextualized objects, the "standing-reserve", reduced to functional utility (Heidegger [1954] 1977). Rather, technology must also undergo a "secondary instrumentalization", which reappropriates context, giving an artifact its social meaning and adding additional normative content (Feenberg 2002). For Feenberg, this process even has the potential to bring about a reconfiguration and transformation of technology according to human interests.

By bringing together critical theory and social constructivism, Feenberg generates a dialectic between instrumentalist and determinist perspectives: technology indeed shapes the social order but at the same time humans maintain their agency to change technology (for an in-depth discussion of agency, see Chap. 11). This allows him to propose a more optimistic account, wherein technology is not always oppressive but can instead serve as a medium for expression of social values, opening up the possibility of democratizing technical systems. To paraphrase Feenberg (2010a), it is through technology that today's values become the facts of tomorrow. This idea in particular brings Feenberg's philosophy of technology into close proximity with John Dewey's, which I turn to now.

17.3.3 Dewey's Pragmatist Philosophy of Technology

John Dewey is widely known as a philosopher of American pragmatism, whose near-century's worth of writing spanned topics from logic and epistemology to politics and education. Dewey is less commonly known, however, as a philosopher of technology, although there is growing recognition of his ideas on technology thanks to sustained efforts by scholars such as Larry Hickman (1990; 2001), as well as the recent publication of a previously lost Dewey manuscript (2012). It is fitting to end our survey with Dewey, who ties together several of the themes discussed above.

Despite coming from distinct intellectual traditions, Dewey shares Heidegger's view of the ontological priority of technology over science. Also, similar to Heidegger, Dewey's ([1929] 1984a) view of technology is best understood within a broader critique of Western epistemology and its "spectator" theory of knowledge. For Dewey, even more so than for Heidegger, human existence is a practical affair: we are not spectators of nature, perceiving an external world from which we ascertain knowledge, but rather are active participants in it. Knowledge, therefore, is not a set of universal propositions but rather is context-dependent and directed towards a use or end—not simply knowledge but *knowledge-for*.

Dewey's conception of technology follows from this pragmatist perspective. For Dewey, knowing itself can be understood as a form of technology, where technology is roughly defined as a method of inquiry and set of tools for resolving problematic situations. This differs in an important way from Heidegger view of technology as a mode of revealing. Dewey offers a naturalized account of technology, which—contra Heidegger—is not a uniquely modern (mis)understanding of being, but rather a fundamental aspect of how humans cope with the natural and social world. Like Feenberg, Dewey also rejects Heidegger's essentialism: there is no 'essence' of technology or of the technological; technology instead describes both the process and product of inquiry, which is not fixed but rather evolves to fit context and human needs. As Dewey ([1930] 1984b) put it: "'Technology' signifies all the intelligent techniques by which the energies of nature and man are directed and used in satisfaction of human needs" (270).

While this definition might seem somewhat broad, Dewey's writings on technology are in fact subtle and multifaceted with deep links to his pragmatism, as explored in detail by Hickman (1990; 2001). For want of space, I will focus on one central aspect of Dewey's philosophy of technology, which is his treatment of means and ends. A first point to make is that Dewey rejected the notion of fixed ends or "ideals", which he argued had been emphasized in Western philosophy since antiquity. Rather, he sought to elevate means, which he believed had been wrongly denigrated as "menial" and subordinated to ends. A vestige of this view is perhaps contained in the positivist position, whereby technology serves as pure means, lacking any content beyond its function in attaining predefined ends. At the core of Dewey's philosophy of technology is the interdependence of means and ends. For Dewey, ends always arise during the process of inquiry, emerging out of a problematic situation that demands resolution. He uses the term "ends-in-view" to emphasize the provisional, revisable nature of ends, which should not be taken as fixed ideals (Dewey [1922] 2008). While ends-in-view form one component of inquiry, means play an equally important role in determining its course.

This interplay between means and ends is best illustrated by way of example. I am faced with a patient who is anaemic: my ends-in-view is to identify the source of blood loss, which suggests a means of investigation, for instance, endoscopy. This produces a new end, namely, to stop the identified source of bleeding. This end, however, is not fixed or final; once achieved it must be re-evaluated within the new situation. For example, if the source of blood loss turns out to be a tumour, additional ends arise which in turn indicate new means for action. This case highlights what for Dewey is a general feature of human activity: ends are not extrinsic givens but rather emerge from within the context of inquiry. Across several of his writings, Dewey warned against pursuing "fixed" ends, which might be said—to paraphrase another American pragmatist—to block the path of inquiry (Peirce [1898] 1960).

What are the implications for healthcare? Dewey would be critical of approaches in medical research and health professions education that reify quality of care based on narrow metrics, such as adherence to specific guidelines or achieving particular biomarker targets, which impose fixed ends but often overlook their means and potential harms. Likewise, he would disparage medical technologies focused on preset performance targets to define success, such as a high area under the receiver operating characteristic curve for a machine learning model, which may indicate high sensitivity and specificity but does not attend to use within a wider clinical context and impact on patient-centered outcomes (for discussion, see Oren et al. 2020). For Dewey, ends must not be extrinsic, built into "off the shelf" technologies according to prevailing interests, but rather should arise from inquiry aimed at ameliorating the human condition, and therefore should be democratically instantiated (Waks 1999). Dewey (2012) rejects the positivist idea of technology as pure means to external ends, which renders technology "indifferent" to its uses, and "signifies that something else is sure to decide the uses to which it is put" (244). For Dewey, that "something else" included not only "traditions and customs" but also "rules of business", words written—not incidentally—during the Golden Age of American capitalism. This lesson remains especially salient today, amidst growing recognition of powerful commercial interests driving the technologization of healthcare, with advances in digital health technologies often coeval with shifts towards greater privatization (Wamsley and Chin-Yee 2021). Healthcare professionals must remain vigilant of where the ends of technologies derive, and ensure that providers, patients, and their communities are engaged in the co-construction of tools. Here Dewey, not unlike Feenberg and the social constructivists, shows us how ethical considerations and questions of values play a crucial role in the determination of technology's ends and means.

17.4 Conclusion: Technology and the Practical Art of Medicine

We are now in a better position to revisit the false dichotomy posed at the outset, that incalcitrant dualism between the art and science of medicine which has the propensity to devolve into arguments over medicine's "two cultures" (Wulff 1999; Snow [1959] 1993), maintaining an erroneous divide between facts and values. As

Kathryn Montgomery (2005) points out, medicine is best understood as a practice, or as Dewey might put it, a *practical art*.

This chapter has highlighted how medical technologies cannot simply be understood as extensions of medical science but rather form a fundamental part of medicine as a practical art. And as practical art, technology is one locus where facts and values come together, an idea supported by all three philosophers discussed above. I conclude by reiterating three main themes from this discussion, which help dispel myths of the positivist position and offer important lessons for health profession education. Each theme not only serves as a starting point for critical dialogue between medical educators and learners but might also be integrated into medical curricula as a basis for teaching on the ethical and social dimensions of technology, supplementing a tendency for technological education to focus on acquisition of discrete skills and competencies while often overlooking broader questions of context and application (Table 17.1).

17.4.1 Technology as a Way of Thinking

The first lesson, common to both Heidegger and Dewey, is that technology does not simply refer to material artifacts or "mechanical forms" but rather encompasses a way of thinking or being-in-the-world (Dewey [1930] 1984; Heidegger [1927] 1996). Applied to healthcare, this lesson occasions reflection on how technology and technological thinking shapes our 'ordering' of the clinical world and interactions with patients. It warns against a tendency to see patients as mere 'standing-reserve', reducing their experiences to data, which serve as inputs for use in algorithms (Chin-Yee and Upshur 2019). Healthcare professionals must be cognizant that these tools form only one mode of revealing, powerful yet limited. To truly support a 'free relationship' with technology, educators must create space for other forms of 'revealing', for example, by helping to cultivate those "moments of being" which give meaning to practice (Kumagai et al. 2018). Knowledge from the social sciences and humanities, including philosophy, can help foster this epistemic humility and pluralism with respect to medicine's "ways of knowing" (Chin-Yee et al. 2018; Thomas et al. 2020). This lesson avoids training healthcare professionals who are technically proficient at gathering data and applying algorithms but who are unable to step outside this mode of revealing to see a clinical problem from a different angle or appreciating another perspective not captured by the algorithm.

17.4.2 Technology as Value-Laden

The second lesson, found in all three thinkers, recognizes technology not as the value-neutral application of science but rather as "teeming with values and potentialities"

(Hickman 1990), which reflect a range of social choices. This lesson in particular requires us to examine those choices and the biases they encode. It raises critical questions, such as ‘Who is included?’, ‘Who is excluded?’, and ‘Whose interests does a given technology serve?’ Such questions should be continually raised in medical research and health professions education, serving as opportunities to reconfigure and transform technology’s means and ends, orienting them towards greater equity and inclusion.

17.4.3 Technology as a Continuum of Means and Ends

The last lesson is that technology does not exist as pure means dictated by external ends but rather involves a continuum of means and ends, which develop iteratively through the process of inquiry. This lesson teaches that technology’s ends are fallible, and alongside means, require revision and adjustment to context.

Returning finally to the opening example of Watson for Oncology, performance of such a tool cannot be evaluated solely on the basis of pre-defined ends, such as agreement with expert consensus as is often the case in appraisal of algorithmic decision-making (Tupasela and Di Nucci 2020). Rather, it requires that we situate the technology’s use within the uncertain situation *in its totality*, in this case, the clinical problem of selecting treatment for a patient with a diagnosis of cancer. From here we ask: ‘What are the ends-in-view?’ Such a question focuses the problem: Is it to provide the ‘best’ treatment as defined by the latest clinical trial evidence? Is it to tailor ‘precision’ therapy for a specific set of genomic biomarkers? Or, rather, is it to treat *this* particular person in a way that considers their individual context and values? Such ends differ in important ways and suggest different means, calling for different tools or even different modes of thinking altogether.

Healthcare professionals must remain sceptical of approaches that reify ends, defining success in narrow terms, and instead indefatigably scrutinize means and ends for their ability to serve the needs of clinicians, patients, and their communities. In this endeavour clinicians, educators and philosophers all play a critical role, offering the knowledge and values to shape the medical technologies of tomorrow. The rapid pace of technological change can be overwhelming for many, giving rise to a tendency to relinquish control and adopt a determinist perspective—recalling Heidegger, that “only a god can save us now”. However, to end on a more optimistic note, we might also reflect on a quote from Dewey ([1934] 2013), who argues for a different type of faith:

> Faith in the power of intelligence to imagine a future which is the projection of the desirable in the present, and to invent the instrumentalities of its realization, is our salvation. And it is a faith which must be nurtured and made articulate: surely a sufficiently large task for our philosophy (48).

Table 17.1 Practice points

1	Philosophy of technology teaches us to think critically about medical technologies and offers important lessons for health professions education
2	Technology does not simply refer to material artifacts but instead describes a particular way of thinking and interacting with the world
3	Technology is not value-neutral but rather reflects a range of social choices and human values
4	Technology does not serve as pure means to fixed ends but instead involves a continuum of means and ends which evolve through the process of inquiry
5	These lessons support more reflexive engagement with technology amongst healthcare professionals to better address the needs of clinicians, patients, and their communities

References

Ajjawi, Rola, and Kevin Eva. 2021. "The Problems with Solutions." *Medical Education* 55: 2–3.

Benjamin, Ruha. 2019a. "Assessing Risk, Automating Racism." *Science* 366: 421–422.

Benjamin, Ruha. 2019b. *Race After Technology*. Cambridge, UK: Wiley.

Bijker, Wiebe E, Thomas Parke Hughes, and Trevor Pinch. 2012. *The Social Construction of Technological Systems*. Cambridge, MA: MIT Press.

Bluhm, Robyn, and Kirstin Borgerson. 2011. "Evidence-Based Medicine." In *Philosophy of Medicine*, edited by Dave M Gabbay, Paul Thagard, and John Woods, 203–237. North Holland: Elsevier.

Borgmann, Albert. 1984. *Technology and the Character of Contemporary Life*. Chicago: University of Chicago Press,

Braun, Lundy. 2014. *Breathing Race into the Machine*. Minneapolis: University of Minnesota Press.

Burger-Lux, M. Janet, and Robert P. Heaney. 1986. "For Better and Worse: The Technological Imperative in Health Care." *Social Science & Medicine* 22: 1313–1320.

Chin-Yee, Benjamin, and Ross Upshur. 2018. "Clinical Judgement in the Era of Big Data and Predictive Analytics." *Journal of Evaluation in Clinical Practice* 24: 638–645.

Chin-Yee, Benjamin, and Ross Upshur. 2019. "Three Problems with Big Data and Artificial Intelligence in Medicine." *Perspectives in Biology and Medicine* 62: 237–256.

Chin-Yee, Benjamin, Atara Messinger, and L Trevor Young. 2018. "Three Visions of Doctoring: A Gadamerian Dialogue." *Advances in Health Sciences Education* 24 (2): 403–412.

Dewey, John. [1922] 2008. *The Middle Works of John Dewey, 1899–1924:1922, Human Nature and Conduct.* Carbondale, IL: Southern Illinois University Press.

Dewey, John. [1929] 1984a. *The Later Works, 1925–1953: 1929, The Quest for* Certainty. Carbondale IL: Southern Illinois University Press.

Dewey, John. [1930] 1984b. *The Later Works, 1925–1953: 1929–1930, Essays, the Sources of a Science of Education, Individualism, Old and New, and Construction and Criticism.* Carbondale IL: Southern Illinois University Press.

Dewey, John. [1934] 2013. *A Common Faith.* New Haven, CT: Yale University Press.

Dewey, John. 2012. *Unmodern Philosophy and Modern Philosophy*. Carbondale IL: Southern Illinois University Press.

Dreyus, Hubert L., and Charles Spinosa. 1997. "Highway Bridges and Feasts: Heidegger and Borgmann on How to Affirm Technology." *Man and World* 30: 159–178.

Dubber, Markus Dirk, Frank Pasquale, and Sunit Das. 2020. *The Oxford Handbook of Ethics of AI*. USA: Oxford University Press.

Eubanks, Virginia. 2018. *Automating Inequality*: *How High-Tech Tools Profile, Police, and Punish the Poor*. New York: St. Martin's Press.
Feenberg, Andrew. 1991. *Critical Theory of Technology*. Oxford: Oxford University Press.
Feenberg, Andrew. 2002. *Transforming Technology*. Oxford: Oxford University Press.
Feenberg, Andrew. 2010a. "Ten Paradoxes of Technology." *Techné* 14: 3–15.
Feenberg, Andrew. 2010b. *Between Reason and Experience*. Cambridge: MIT Press.
Franssen, Maarten, Gert-Jan Lokhorst, and Ibo Van de Poel. 2009. "Philosophy of Technology." In *Stanford Encyclopedia of Philosophy (Fall 2018 Edition)*, edited by Edward N. Zalta. https://plato.stanford.edu/cgi-bin/encyclopedia/archinfo.cgi?entry=technology.
Fuller, Jonathan. 2015. "The Art of Medicine." *Canadian Medical Association Journal* 187: 1078–1078.
Heidegger, Martin. [1927] 1996. *Being and Time*. New York: SUNY Press.
Heidegger, Martin. [1954] 1977. "The Question Concerning Technology." In *The Question Concerning Technology and Other Essays*, Martin Heidegger, 287–317. Translated by William Lovitt. New York: Harper & Row Publishers, Inc.
Heidegger, Martin. [1966] 2017. "'Only a God Can Save Us': The Spiegel Interview". In *Heidegger: The Man and the Thinker*, edited by Thomas Sheehan. Oxfordshire: Routledge.
Hickman, Larry A. 1990. *John Dewey's Pragmatic Technology*. Bloomington: Indiana University Press.
Hickman, Larry A. 2001. *Philosophical Tools for Technological Culture*. Bloomington: Indiana University Press.
IBM. 2022. "IBM Is Selling Off Watson Health to a Private Equity Firm." *New York Times*, January 21. https://www.nytimes.com/2022/01/21/business/ibm-watson-health.html.
Kumagai, Arno K., Lisa Richardson, Sarah Khan, and Ayelet Kuper. 2018. "Dialogues on the Threshold: Dialogical Learning for Humanism and Justice." *Academic Medicine* 93: 1778–1783.
Latour, Bruno. 1993. *The Pasteurization of France*. Cambridge: Harvard University Press.
Mitcham, Carl. 1994. *Thinking Through Technology*. Chicago: University of Chicago Press.
Montgomery, Kathryn. 2005. *How Doctors Think: Clinical Judgment and the Practice of Medicine*. Oxford: Oxford University Press.
Noble, Safiya Umoja. 2018. *Algorithms of Oppression: How Search Engines Reinforce Racism.* New York: New York University Press.
Oren, Ohad, Bernard J. Gersh, and Deepak L. Bhatt. 2020. "Artificial Intelligence in Medical Imaging: Switching from Radiographic Pathological Data to Clinically Meaningful Endpoints." *The Lancet Digital Health* 2: e486–e488.
Peirce, Charles Sanders. [1898] 1960. *Collected Papers of Charles Sanders Peirce*. Cambridge: Harvard University Press.
Pickstone, John V. 1993. "Ways of Knowing: Towards a Historical Sociology of Science, Technology and Medicine." *The British Journal for the History of Science* 26: 433–458.
Sackett, David L. 2005. *Clinical Epidemiology: A Basic Science for Clinical Medicine*. Philadelphia: Wolters Kluwer.
Sandelowski, Margarete. 2000. "'This Most Dangerous Instrument': Propriety, Power, and the Vaginal Speculum." *Journal of Obstetric, Gynecologic, & Neonatal Nursing* 29: 73–82.
Snow, CP. [1959] 1993. *The Two Cultures*. Cambridge: Cambridge University Press.
Solomon, Miriam. 2015. *Making Medical Knowledge*. Oxford: Oxford University Press.
Thomas, Aliki, Ayelet Kuper, Benjamin Chin-Yee, and Melissa Park. 2020. "What Is "Shared" in Shared Decision-Making? Philosophical Perspectives, Epistemic Justice, and Implications for Health Professions Education." *Journal of Evaluation in Clinical Practice* 26: 409–418.
Topol, Eric J. 2019. "High-Performance Medicine: The Convergence of Human and Artificial Intelligence." *Nature medicine*: 1–13.
Tupasela, Aaro, and Ezio Di Nucci. 2020. "Concordance as evidence in the Watson for Oncology Decision-Support System." *AI & Society* 35: 811–818.
Waks, Leonard J. 1999. "The Means-Ends Continuum and the Reconciliation of Science and Art in the Later Works of John Dewey." *Transactions of the Charles S. Peirce Society* 35: 595–611.

Wamsley, Dillon, and Benjamin Chin-Yee. 2021. "COVID-19, Digital Health Technology and the Politics of the Unprecedented." *Big Data and Society* 8 (1): 1–10.

Whitehead, Cynthia, and Ayelet Kuper. 2015. "A False Dichotomy." *Canadian Medical Association Journal* 187: 683–684.

Winner, Langdon. 1978. *Autonomous Technology*. Cambridge: MIT Press.

Winner, Langdon. 1980. "Do Artifacts Have Politics." *Daedalus* 109: 121–136.

Wulff, Henrik. 1999. "The Two Cultures of Medicine: Objective Facts Versus Subjectivity and Values." *Journal of the Royal Society of Medicine* 92: 549–552.