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REVIEW ARTICLE

PHILOSOPHY OF TECHNOLOGY AND ITS FOUNDATIONAL PRINCIPLES

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ABSTRACT

This paper discusses philosophy of technology as a critical, reflective examination of the nature of technology as well as the effects and transformation of technologies upon human knowledge, activities, societies and environments (Umwelt). The aim of philosophy of technology is to understand, evaluate and criticize the ways in which technologies reflect, as well as change the human life individually, socially and politically.Secondly, philosophy of technology is closely related to the philosophy of science, which offers much attention to the methodology and epistemology. Thirdly for Husserl, technique "is a mere art of achieving technical rules", but for Heidegger it is merely in bringing out the meaning of technology. Finally, theories supporting technology are explained: such as common sense theory, theory of truth or theory of pragmatism, theory of epistemology, and theory of experience. Thus, the traditional values of knowledge, instruments, techniques and tools used in an ancient society epitomizes mankind from its earliest days as it was used by engineers in the modern world or when engineers aligned themselves with science in regularly applying scientific knowledge to technical practice in our everyday life.

INTRODUCTION

Since the beginning of human race, there is a body of opinion according to which human invent technology and technology invents humans. Philosophy of technology as a branch of professional philosophy is relatively recent. Traditional branches of philosophy such as metaphysics and ethics are almost two and a half millennia old. Philosophy of science as a specialized brand of technical philosophy, by contrast, stems from the second and third decades of the twentieth century. Despite the importance of technology to human life and society throughout human history (and, indeed, prehistory), there has not been a continuous tradition of philosophy of technology. Indeed, one should not forget that there have been sporadic major contributions to this field among the classical philosophers. As for instance, Socrates, Plato and Aristotle discussed the crafts, expertise and *techne.* Socrates and Plato compared and contrasted the concrete and effective knowledge possessed by craftspeople with the spurious claims to knowledge of ethical and political matters on the part of politicians of the day. On the other hand, Socrates and Plato distinguished the narrow, concrete and specialized craft knowledge with the comprehensive wisdom pursued by genuine philosophy. According to Plato, training in mathematics should be regarded as an ideal prerequisite for the study of ethics and politics. Thus, in his later "unwritten doctrine" conflated philosophical knowledge with a higher form of knowledge of numbers. On the other hand, Aristotle strongly contrasted practical knowledge which is gained from mentors and learned by example is dependent on intuitive judgment and is based on life experience, with precise and explicit mathematical knowledge. Almost two thousand years later Francis Bacon emphasized the role of technology in experimental knowledge and advocated that it will contribute to the prosperity and welfare of society. Bacon took seriously the importance of craft knowledge in gaining upper hand on theoretical knowledge and mastery over nature. In this endeavor, Bacon differed greatly from the "British empiricists" (Locke, Berkeley, Hume and Mill), who are generally considered his philosophical progeny during the next three centuries; whereas the latter concentrated on the association of ideas based on perceptual knowledge and did not give adequate importance to knowledge which is based on practical, manipulative activity. What we can observe in the 19th century is that great minds like Henri de Saint-Simon and August Comte in France, as well as Karl Marx in Germany, devoted much attention to the role of technology in the

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development of society. Comte and Saint-Simon did not focus on the details of particular technologies (though Comte had a fairly detailed knowledge of mathematical physics) but both did make the concept of "industrial society" central to their conceptions of the culmination of historical development and the social structure of contemporary society (Comte being the father of sociology). Marx, who characterized the essence of contemporary society as capitalism rather than as industrialism in general, analyzed particular technologies with respect to their effects on workers and their contribution to productivity. Philosophy of technology is a field of philosophy that involves a wide variety of branches of philosophy. Philosophy of technology involves philosophy of science, theory of knowledge, philosophy of action, ethics, political philosophy, and also involve aesthetics, metaphysics and philosophy of religion as well. Within analytical philosophy, focus on philosophy of science and ethics have involved disjoint classes of specialists. Not only does the field demand simultaneous engagement in a diversity of branches of philosophy, but also contributors to philosophy of technology have come from a number of schools of philosophy. These diverse schools for most of the 20th century did not communicate with one another. Often they did not respect or take seriously one another's style and product. The split between analytic and continental philosophy began around the turn of the 20th century. After the early exchanges between the phenomenologist Edmund Husserl and the grandfather of logical analytical philosophy, Gottlob Frege, for instance, or the early mutual and co-respective awareness of Martin Heidegger and Rudolf Carnap, despite the harsh criticisms of the former by the latter, analytic and Continental philosophy remained mutually incommunicado for at least three-quarters of the century. There are contributions to philosophy of technology not only in the analytical and linguistic vein, as well as from the phenomenological, existential and hermeneutic traditions; there have also been further contributions from British social constructionists, French postmodernists and American pragmatists (Peirce 1998).

Concept of Technology

The word "*technology*" comes from the Greek word "*techne*" which means an art, craft or a skill and "*logos*" or "*logy*" means science or study. A person is said to be technically qualified when he is found to be skilled or practically conversant with some particular art or subject. Again the word *techne* in ancient Greece signifies the knowledge or the discipline associated with a form of *poiesis*. For example, medicine is a *techne* that aims at healing the sick; carpentry is a *techne* that aims at building from wood. The terms "*technique*" and "*technology*" have their roots in the ancient Greek notion of "*techne*" (art, or craft-knowledge), that is, the body of knowledge associated with a particular practice of making (Parry 2008). Originally this term referred to a carpenter's craft-knowledge in relation to the making of objects from wood; but later it was extended to include all sorts of craftsmanship, such as captain of a ship's *techne* of piloting a ship, the musician's *techne* of playing a particular kind of instrument, the farmer's *techne* of working the land, the statesman's techne of governing a state or polis, or the physician's *techne* of healing patients (Nye 2006). According to Plato, (Laws, Book X) what craftsmen do when making artifacts is to imitate nature's craftsmanship – a view that was widely endorsed in ancient Greek philosophy and continued to play an important role in later stages of thinking about technology. On Plato's view, then, natural objects and man-made objects come into being in similar ways, both being made by an agent according to pre-determined plans. That is to say that t*echne* includes a purpose and a meaning for *artifacts*. That is why the Greeks bring in these aspects of *techne* into the realm of nature and considered all of nature in teleological terms. The essence of natural things includes a purpose just as does the essence of *artifacts*. We may also take into consideration that the Greek word "*tekhnologia*" stands for systematic treatment of an art (or craft)). The root "*techne*" combines the meaning of an art and a technique, involving both knowledge of the relevant principles and an ability to achieve the appropriate results (Wheelwright 1966). In other words, we may say that "*technique*" involves the practical skills of knowing and doing (Hall 1978). The root "*logos*" has wider meaning including argument, explanation, and principle but its most relevant use is probably "*to reason*" (Willoughby 1990). Technology, thus, encompasses reasoned application. It however has always meant more than the abstract study because of the emphasis on application and function. In view of these reflections, we can say that technology is referred to as the study of technical processes and objects and the term "*technique*" refers to the individual technical means and its genuine application processes.

Techne

In "*techne*" man works his being out and articulates himself. *Praxis* is the prime *techne*. It is not the mere application of theories, vision or attentive outlook, but is an active impetus and base. Doing is the best of knowing and learning. Theory/practice, thought/action, theorization/application, pure knowledge/applied knowledge –whatever pair of terms we prefer, the fact remains that they are integrally related, interpenetrative and interactive. All these pairs represent the two main aspects of our nature, so to say, *cognitive* and *conative*. Scientists' aims of knowing clearly and correctly are already available with them. Their observation is not random or aimless. They know what they are looking for. In an inarticulate way, they know what is calculable, what is mappable, what is shapeable and systematizable. Both *epistemology* and technology are *ontologically* informed. Before reality is grasped, brought out or controlled, it is somehow available with the knowing mind (Heidegger 1977). Our common understanding of technology is centered on a machine or instrumental device which is used for the purpose of getting something done quickly and efficiently. Ordinarily, people use technology to improve their ability to do work. Man is a tool-using animal (*homo-technikos*) in a complex sense. Not only does he use tools of "*external*" origin but also he uses his feet, hands and several other parts of his body as a tool. Both types of tools are helpful to him to adjust himself with the world around him. For example, his eyes and brain informs him of the world he lives in and in a way takes him to that world of familiarity. The intimate relationship among our bodily organs provides clues to the proper understanding of the two-sided characteristics of the relationship between technology and human beings. Technology is a way of expressing what is not expressed, a way of bringing out that has not been brought out earlier. It is a sort of challenge to nature, to know what is there in nature. For example, nature has so many resources and energies in it. Different forms and sources of energies, different kinds of metals etc. are in it.

Stones, trees, waters and many other things, ordinarily taken to be insignificant are of immense value to human life or in fact part of it. The service of technology is required for bringing the concealed properties of all these things for our uses (Chattopadhyaya 1996).

The term "*techne*" which has been usually translated as "*art*" has lost its currency today; nowadays this is imprecise, since for us art concerns essentially the beautiful or aesthetic expression. Plato, Aristotle, and the great doctor-philosopher Hippocrates tell us that the characteristics of *techne* are parallel to those of episteme that is, science insofar as both are types of knowledge, which demonstrate the reasons for what is observed empirically. Knowledge is said to have two concerns; the first concern is of acquiring pure knowledge and the second aspect of knowledge is of its function, Hence, in this sense we can say that the ideal of technology is clearly prefigured in the Greek notion of *techne*. More precisely, technology in the Greek tradition precedes and is more fundamental than sciences. Heidegger holds the view that the reason of such a misunderstanding of technology lies deeply in the process of artificial transformation of reason into rationality. It has paved the way of appropriating and transforming science into a kind of *know-how*. That is why we tend to identify technology with machine technology. The central idea of our contention is that technology is stripped off its ontological character and made to become a mere instrument, which is far from truth. The constituting of technology, in the full modern sense of that term is a consequence of our usual way of mixing science with technology; indeed, it is science that furnishes the theoretical grounds for efficacious doing. (The traditional science of episteme was used for the theoretical foundation of the ancient *techne* and was essentially constituted by philosophical reflection.). This new science not only rapidly led to detailed knowledge of the natural world, which allowed for more adequate explanations of the success of many techniques already used; it also inaugurated a process by which newly acquired knowledge was immediately applied toward the creation of new techniques and was even sought for the sake of some technical application.

Technological knowledge: Defining characteristics

The defining characteristic of technological knowledge, however, is its relationship to activity. Although, technological knowledge is considered to have its own abstract concepts, theories, and rules, as well as its own structure and dynamics of change, yet, these are essentially applications to real situations. Technological knowledge arises from and is embedded in human activity in contrast to scientific knowledge which is an expression of the physical world and its phenomena. As Landies (1980) observes, while the intellectual is at the heart of the technological process, the process itself consists of the acquisition and application of a corpus of knowledge concerning technique, that is, ways of doing things (Landies 1980). These reflections suggest that it is through activity that technological knowledge is defined. It is an activity, which establishes and orders the framework within which technological knowledge is generated and used. Because of the link with specific activity, technological knowledge cannot be easily categorized and codified as in the case of scientific knowledge. Technology finds its best expression through the specific application of knowledge and technique to particular technological activities. For this reason it is not considered a discipline in the sense that mathematics or physics is Skolimowski (1972), for example, suggests that there is no uniform pattern of "technological thinking," or universals characterizing a "discipline of technology". The application of technology requires the integration of a variety of heterogeneous factors, which are both "multi channeled and multileveled", and that specific branch of technology condition is specific modes of thinking (Skolimowski 1966). Technology, in other words, makes use of formal knowledge, but its application is interdisciplinary and specific to particular activities. There is a technology of surveying, civil engineering, architecture, biochemistry, hog farming and countless others, but technology is not a coherent discipline in the general sense. Technical action is based on a technology that is supported by a system, which has theoretical as well as practical elements coupled into a theory of technology.

Technique and Technology

The terms technique and technology are used in diverse ways. As we know, these terms have already occupied in the history of human civilization as human history has undergone different developments of technical action and of technology. The concept "*technique*" comes from the Greek word '*technikos'*, relating to crafts and means individual or guild that moderately delivers the procedure of knowledge and its products. In 19th century, technique was understood as an applied empirical natural science, particularly in thermodynamics and electro-technology and in 20th century it was understood as chemistry or pharmacy, nuclear physics and the biotechnology (Skolimowski 1966). In this sense, the term "technology" acquired limited usage in the late 19th century as a means to refer to the application of science (knowledge) to the making and use of artifacts. Ever since the beginning of Western philosophy, philosophers of pre- 19th century have been reflecting on technology-related matters, without a specific intention of understanding technology. Rather, they examined technology in the context of more general philosophical projects which were aimed at clarifying traditional philosophical issues other than technology (Fischer 1996). It is to say that before the mid to late 19th century no philosopher considered himself as being a specialized philosopher of technology, or even as a general philosopher with an explicit concern for understanding the phenomenon of technology as such, and there were no full-fledged philosophies of technology had been involved.

One of the reasons for such an understanding is that before the mid to late 19th century, technology had not yet become the tremendously powerful and ubiquitously manifest phenomenon that it would have later become (Heidegger 1977). Technology in this scheme of things encounters nature as raw materials, not as a world that emerges out of itself, a *physis*, but rather as stuff awaiting transformation into whatever we desire. The world was understood mechanistically without providing any *teleological* importance, which looked at nature to be controlled and used without any inner purpose. Whereas from the standpoint of teleology, the world is full of meaning; all that exist are endowed with meaning as well the world of nature and human history. In this image of rationality, knowledge is an activity, which mirrors the objective meaning of things and therefore it acquires a positive moral value. The rational behavior, being

compatible with an objective order, is always moral and it directs towards more and more new values. No doubt, the West has made enormous technical advances on the basis of this understanding of technology. In such a perspective, nothing restrains us in exploitation of the world. Everything is exposed to an analytic intelligence that decomposes it into usable parts. Our means have become ever more efficient and powerful. In the 19th century, it became commonplace to view modernity as an unending progress toward the fulfillment of human needs through technological advance. It was this notion that captured the imagination of the Japanese in the Meiji era and led to the modernization of Japanese society in the 20th century. The objectives of any given society can no longer be specified in knowledge of some sort, a techne or an episteme, as they were for the Greeks. They remain purely subjective arbitrary choices and have no inner strength to guide us. This has led to a crisis of civilization from which there seems no escape. The disaster of such a society found its wide application in all spheres of human activity, as for instance, in science, techniques, economy, organization of collective life etc., and rationality has been universally identified with perfection, splendor, profit and material abundance. As a consequence, one feels obliged to rationalize one's own existence, thinking and acting. What we wanted to state here is that the transition from objective to subjective reason caused reason to become exclusively an instrument; its only value became the utilitarian one. The results and consequences of the transformation of the instrumentalization of reason have developed societies without ideologies and outlook. As the 20th century proceeds, from world wars to concentration camps to environmental catastrophes, it becomes more and more difficult to ignore the strange aimlessness of modernity. No doubt, philosophy of technology has emerged in our times as a critique of modernity.

Technique: Husserlian understanding

According to Husserl, technique "is a mere art of achieving through a calculation according to technical rules". With the appropriate use of logical connectives like *"and", "or", "implies", "is equal to",* one can play on the game of logic without going into the meaning of it. For example, one can pertinently raise the question regarding the very meaning of logical constants in terms of which rules of inference are framed and used. The validity of logical inference, deductive as well as inductive, depends very much on the meaning of logical constants. Husserl maintains that logic and mathematics cease to be branches of serious learning and original thinking if the deeper meanings of the seeming technical process are not inquired into and grasped. The true learner must know the meanings of such signs as *"+", "x", "-", "="*. The results of the failure to grasp the deeper meanings of mathematics and logic do not remain confined only to the superficial and formal level of these branches of knowledge. Such a failure adversely affects human knowledge on every conceivable objects of experience. One need not question the legitimacy of the formal-logical forms. If we raise such questions as how mathematical techniques are bestowed with meanings, we land ourselves into a dangerous area of unquestioned practice or playing with empty formula. When the inner meanings or "ideal unities" of the laws and mathematics are forgotten, scientific thinking and practice lose their symbolic character and gradually becomes "unlived" and "mechanical". Husserl is strongly opposed to this methodological tendency to "*superficialize*" and "*technize*" such profound branches of learning as mathematics and logic. The root meanings are bestowing fundamentals of all forms of science and technology (Husserl 1954). Husserl's analysis of modern science is contained in his later work" Crisis". For Husserl, the science inaugurated by Galileo is a symbol for the historical development of modern science. The basic feature of the Galilean style is the cleavage between the world as it presents itself in everyday experience (the life-world) and as it is in scientific truth and reality. The perceptual world is not accepted as its face value; on the contrary, reality is taken to be a concealed mathematical structure and disclosing this hidden mathematical structure is the task of physics and thus, there is a need for a as the way of access to the hidden reality.

Husserl sees science especially Galilean science as a problem. To see science as a problem does not mean questioning its technical validity. What is involved here is the interpretation of science, or what Husserl calls 'the sense of science' of Galilean style with the conception of nature possessing a mathematical structure. The methods of science once invented tend to get formalized and undergo a process of 'technization' in the course of which their application becomes routine. But understanding involves going to the root of the problem. Husserl, therefore, developed the contrast between technical understanding and radical understanding. The model of exact knowledge or '*episteme'* is mathematical knowledge; for Galileo, this took the specific form of geometrical knowledge. According to Husserl, in our day to day life (life-world), we encounter things which have shapes, but these shapes are not geometrical signs in the exact sense. The determination of such natural shapes is governed by the demands of practical action and practical purpose. This process culminated in the logicization of geometry in the present century. This trend towards formalization becomes the style of exact modern science. In a formalized discipline, the terms are divested of all intuitive contents and are defined in terms of relations obtaining between them and by way of the operations which can be performed on them. Formalization leads to the establishment of systems and symbols and of rules of operation on those symbols. Having explored the Husserlian understanding of technology, in the next section we will look into Heideggerian concept of technology.

Heidegger and the term Technology

Martin Heidegger, a major 20th century German philosopher argued that modernity is characterized by the triumph of technology over every other value. He noted that Greek philosophy had already based its understanding of being on technical making and argued that this starting point culminates in modern technology. Heidegger is mainly interested in bringing out the meaning of technology. His formulation of the basic question is: "what is the essence of technology" and not "what is technology"? Obviously he uses the term essence (*Wesen*) in its German sense as enduring significance. He does not aim to providing an "instrumental" or "anthropological" definition of technology. Heidegger refers to four concepts of cause as explicated by Aristotle - material, formal, final and efficient- and thereby brings out their unified sense of responsibility of "*bringing-forth*" (*Hervorbringen*) something in appearance, something into presence (*poiesis*). To talk of bringing forth hardly makes any sense unless something concealed or unexpressed is presupposed. It is a way of

revealing truth. And here lies its cognitive import, its affinity to episteme. So it would be wrong to suppose technology as a mere means or instrumental in character (Chattopadhyaya 1996). Where the Greeks took *techne* as the model of being in theory, we have transformed being technically in practice. Our *metaphysics* is not in our heads but consists in the real technical conquest of the earth. This conquest transforms everything into raw materials for technical processes, including human beings themselves. But, Heidegger argues, although we may control the world through our technology, we do not control our own obsession with control. Something lies behind technology, a mystery we cannot unravel from our technological standpoint. Where we are headed is a mystery too. The West in Heidegger's view has reached the end of its rope.

While one reason for the emergence of philosophy of technology in the 20th century is the rapid development of technology in the last century. According to Heidegger, an important additional reason should be pointed out. Heidegger points out that not only did technology in the 20th century develop more rapidly than in previous centuries and by consequence became a more visible factor in everyday life, but also the nature of technology itself underwent a profound change. The argument is found in a famous lecture that Heidegger gave in 1955, titled "The Question of Technology" (Heidegger, 1962), in which he inquired into the nature of technology. We may note here that although Heidegger actually talked about "*Technik*" (and his inquiry was into "*das Wesen der Technik"*; (Heidegger 1951), but the question he addressed is about technology. In German, "*Technologie*" (technology) is often used to denote modern "high-tech" technologies (such as biotechnology, nanotechnology, etc.), while "*Technik*" is both used to denote the older mechanical crafts and the modern established fields of engineering. ("*Elektrotechnik*", for example, is electrical engineering.) In 21st century, formal knowledge is inextricably linked with the development of science and technology. More recent scholars generally emphasize the importance of knowledge in defining technology. The recognition of the centrality of knowledge leads to conceiving technology as more than artifact, and as more than technique and process (MacDonald 1983).

In accordance with the preceding historical sketch, the history of philosophy of technology – as the history of philosophical thinking about issues concerned with the making of things, the use of *techne*, the challenging of nature and so forth – can be (very) roughly divided into three major periods. The first period runs from Greek antiquity through the Middle Ages. In this period *techne* was conceived of as one among several kinds of human knowledge, namely the craft-knowledge that features in the domain of man-made objects and phenomena. Accordingly, philosophical attention for technology was part of the philosophical examination of human knowledge. The second period runs roughly from the Renaissance through the Industrial Revolution and is characterized by an elevated appreciation for technology as an increasingly manifest but not yet all-pervasive phenomenon. Here, we see a general interest in technology not only as a domain of knowledge but also as a domain of construction, that is, of the making of artifacts with a view on the improvement of human life (for instance, in Francis Bacon's vision of natural philosophy). However, there is no particular philosophical interest yet in technology per se other than the issues that earlier philosophers had also considered. The third period is the contemporary period (from the mid 19th century to the present) in which technology had become such a ubiquitous and important factor in human lives and societies that it began to manifest itself as a subject sui generis of philosophical reflection (Feenberg 1999).

Carl Mitcham (1994) made a fundamental distinction between two principal sub- domains of philosophy of technology, which he called "engineering philosophy of technology" and "humanities philosophy of technology". Engineering philosophy of technology is the philosophical project aimed at understanding the phenomenon of technology as instantiated in the practices of engineers and others working in technological professions. It analyzes "technology from within, and [is] oriented toward an understanding of the technological way of being-in-the-world" (Mitcham 1994). As representatives of engineering philosophy of technology Mitcham lists, among others, Ernst Kapp and Friedrich Dessauer. Humanities philosophy of technology, on the other hand, consists of more general philosophical projects in which technology per se is not principal subject of concern. Rather, technology is taken as a case study that might lead to new insights into a variety of philosophical questions by examining how technology affects human life. A guiding idea in this approach to philosophy of technology is that the design process constitutes the core of technology such that studying the design process is crucial to any project that attempts to understand technology. Thus, philosophers working through this approach often examine design practices, both in the strict context of engineering and in wider contexts such as architecture and industrial design (for example, Vermaas, 2008). In focus are epistemological and methodological questions such as: What kinds of knowledge do engineers have? (for example, Vincenti, 1990; Pitt, 2000; Bucciarelli, 2003; Auyang, 2009; Houkes, 2009). Is there a kind of knowledge that is distinct for engineering? What is the nature of the engineering process and the design process? (For example, Vermaas and others, 2008). What is design? (For example, Houkes, 2008). Is there a specific design/engineering methodology? How do reasoning and decision processes in engineering function? How do engineers deal with uncertainty, failure and error margins? (for example, Bucciarelli, 2003: Chapter 3). Is there any such thing as a technological explanation? If so, what is the structure of technological explanations? (for example, Pitt, 2000: Chapter 4; Pitt, 2009). What is the relation between science and technology and in what way are design processes similar to and different from investigative processes in natural science? (for example, Bunge, 1966).

Science and Technology

Science and technology are determined factors of social development in an industrial country. The relationship among science, technology and industry were brought even closer through research in 20th century. The modern limitation of technology is pulled into the spell of its own dynamics. Actually, the components of scientific knowledge may be found in technology rather than in technique. When speaking of applied science we have to refer to technology, which is understood as the science of engineering. Technique includes not only the total set of useful artificial, concrete objects (artifacts or object systems) but also the sum total of human actions and institutions in which object systems are applied.

That is why Henry Skolimowski argued that technology is something quite different from science (Skolimowski 1966). The structure of thinking in technology; in: C. Mitcham and R. Mackey (eds.) (1972). Philosophy and technology: Readings in the philosophical problems of technology, (Free Press: New York). As he phrased it, science concerns itself with what is, whereas technology concerns itself with what is to be. A few years later, Herbert Simon emphasized this significant distinction in almost the same words, stating that the scientist is concerned with how things are but the engineer looks at how things ought to be (Simon 1969). The notion of 'knowing how' was taken up by Michael Polanyi under the name of tacit knowledge and made a central characteristic feature of technology (Polanyi 1966). An emphasis on tacit knowledge may also be ill-fit for distinguishing the practices of science and technology because the role of tacit knowledge in science may well be more important than current philosophy of science acknowledges, for example in concluding causal relationships on the basis of empirical evidence. Hindle, (1966) however, cautions that there are fundamental historical tensions between science and technology, and that technology is more than applied science (Hindel 1966). Feibleman (1972) distinguishes between pure science, which uses the experimental method in order to formulate theoretical constructs, explicate natural laws, and expand knowledge and applied science, which focuses on applications to purposeful activity and technology which puts applied scientific knowledge to work (Feibleman 1972).

Mackenzie and Wacjman (1985), however, suggest that technology is more than the product of scientific activity. In the case where technology does depend on science, the nature of that relation is not one of technologies obediently working out the `implications' of scientific advance (Mackenzie and Wajcman 1985). Thus, Narin and Olivastro (1992) suggest that there are continuums stretching from basic scientific research through applied research and technology. In some fields, on the other hand, such as communications, computing, medicine, and chemicals, the distinction between science and technology is blurred. The most active areas of high-tech growth are often those that are science intensive (Narin and Olivastro 1992). Mario Bunge defended the view that technology is applied science, but in a subtle way does justice to the differences between science and technology. Bunge acknowledges that technology is about action, but an action heavily underpinned by theory, so to say that is what distinguishes technology from the arts and crafts and puts it on at par with science (Bunge 1979b). Thus, technology arises on one hand, as being included in the domain of technique, while on the other hand it is set off by specific traits (Lenk and Maring 2001). Having understood the relation between science and technology, let us try to look into the concept of "technology" and its assigned principal meanings. Usually, there are three principal meanings to this term:

- Technology (as techniques) is the aggregate of all the artifacts that humans have ever used, from primitive tools to the most complex large-scale technological system.
- Technology is the aggregate of all technical activities such as: invention and discovery; research and development including basic design; final design and actual implementation including to systematize the manufacturing facilities and the steps in successful technological invention; thoughtful designing or planning; embodiment in models and actual implementation; and marketing to society at large.
- Technology is the aggregate of all technical knowledge, from the most specialized techniques and practices to large-scale theoretical scientific technological systems involving engineering knowledge and know-how. We have already discussed earlier a distinction between technique and technology; to a certain extent, this is conventional, but it is not arbitrary. It is not based upon a simple linguistic analysis but reflects certain conceptual differences that may suitably be appended to a double terminology that happens to exist in our languages (Lenk and Maring 2001).

We may also take into consideration that analytic philosophers of technology have always been questioning the relation between science and technology and it was the central issue in one of the earliest discussions among analytic philosophers of technology.

- The objective of natural science is theoretical cognition for its own sake. Technology, on the other hand, is interested in cognition just as far as it is useful to optimize the function and the structure of technical systems.
- The objects of scientific research are natural phenomena and distinguished from human-made artifacts, even if certain natural phenomena can be realized only by large-scale technical instruments. Technology, however, deals with natural effects just as far as they are used in technical systems. Otherwise, it investigates purely technical processes, for instance the kinetics and dynamics of machine tool operations. Moreover, technology is beginning to consider the socio-technical and usage contexts as well. Science is disciplinary, whereas technology is interdisciplinary in principle.
- Regarding methodology, science prefers the isolating abstraction of ideal investigation objects. Technology, on the other hand, deals with real technical objects involved in multidimensional implications. Therefore, technology depends on multi-factor models, simulations and the testing of real prototypes.
- Regarding the characteristics of results, science produces isolated hypotheses and idealized theories, whereas technology generates complex and realistic rules of design by transforming scientific knowledge and integrating it into systematized experience.
- Criteria of quality in science are experimental corroboration, theoretical consistency and approval by the scientific community. In technology, however, quality means the practical success of a technical solution and approval by the engineering and industrial practice. So, technology is pragmatic in the philosophical sense of the word, it replaces truth by success.

These distinctions, to be sure, will require further refinement and enrichment. But even now philosophers demonstrate that science and technology overlap each other to a certain degree; in essential features they are too different to be identified without objection. If at all one searches for the relationship between science and technology, we can only argue that

technology is a genuine type of knowledge and cannot be regarded as 'applied science'. Certain clarifications are given below:

- Science seeks basic understanding of ideas and concepts usually expressed in linguistic or mathematical terms. Technology seeks means for making and doing things. It is a question of process, always expressible in terms of three-dimensional things". One major mode to distinguish between scientific and technological knowledge is intention or purpose.
- The purpose of scientific knowledge is to understand phenomena and the laws of nature. The purpose of technological knowledge, on the other hand, is praxiological, that is, to efficiently control or manipulate the physical world to execute things. Efficiency is the end purpose of technology.
- Science is based on observation and predicts in order to confirm theory; technology predicts in order to influence and control activity.
- Science values the abstract in general; technology put emphasis on instrumentation and application. These distinctions set technology apart from science.

While science seeks to expand knowledge through the investigation and comprehension of reality, suggests Layton (1974), "technology seeks to use knowledge to create a physical and organizational reality according to human design" (Lenk and Maring 2001: p. 40).

The above reflections suggest that philosophy of technology is closely related to philosophy of science, which also offers much attention to methodology and epistemology. Philosopher of technology Joseph Pitt, for example, observed that notwithstanding the parallel with respect to questions that can be asked about technology "there is a startling lack of symmetry with respect to the kinds of questions that have been asked about science and the kinds of questions that have been asked about technology" (Pitt 2000). According to Pitt, philosophers of technology have largely ignored epistemological and methodological questions about technology and have instead focused overtly on issues related to technology and society. Pitt pointed out that social criticism "can come only after we have a deeper understanding of the epistemological dimension of technology and "policy decisions require prior assessment of the knowledge claims, which require good theories of what knowledge is and how to assess it" (Pitt 2000). Thus, philosophers of technology should orient themselves anew with respect to the questions they ask.

Be that as it may, there are more parallels between the philosophies of technology and science. An important endeavor in philosophy of science that is also seen as central in philosophy of technology is conceptual analysis. In the case of philosophy of technology, this involves both concepts related to technology and engineering in general such as "technology", "*technics*", "technique", "machine", "mechanism", "*artifact*", "*artifact* kind", "information", 'system", "efficiency", "risk", etc., and concepts that are specific for the various engineering disciplines. In addition to the above, a renewed interest in metaphysical issues can currently be seen in both philosophy of science and philosophy of technology. For example, while philosophers of science inquire into the nature of the natural kinds that the sciences study, philosophers of technology are developing a parallel interest into the metaphysics of *artifacts* and kinds of artifacts (e.g., Houkes & Vermaas, 2004; Margolis & Laurence, 2007; Franssen, 2008). And finally, philosophers of technology and philosophers of particular special sciences are increasingly beginning to cooperate on questions that are of crucial interest to both fields; a recent example is Krohs & Kroes (2009) on the notion of function in biology and technology.

One of the differences between the states of affairs in philosophy of science and philosophy of technology, however, lies in the relative dominance of continental and analytic indulgence approach. Though there is continental philosophy of science (e.g., Gutting, 2005), it constitutes a small minority in the field in comparison to analytic philosophy of science. In contrast, continental-style philosophy of technology is a domain of considerable size, while analytic-style philosophy of technology is little in comparison. Analytic philosophy of technology has been present since the 1960s but only began the process of becoming the dominant form of philosophy of technology in the early 21st century (Franssen and others, 2009: Sec. 1.3.).

Philosophy of technology as an applied philosophy has a significant contribution to the world. There have been sporadic major contributions to the field among the classical philosophers. Socrates, Plato and Aristotle discussed the crafts, expertise and *techne*. The relation between technological development and cultural values is explored within the norms that could be valid in a contemporary technological society. The traditional values of knowledge, instruments, techniques and tools used in an ancient society epitomizes mankind from its earliest days as it was used by engineers in the modern world or when engineers aligned themselves with science in regularly applying scientific knowledge to technical practice. Furthermore, it is purported to answer whether cultural groups can act as agents of profound transformation. Culture was regarded as an '*object'* which was supposed to be revolutionized. Can culture now invert this position: from the position of object, can it become a subject and act as a transformative principle in the international world order? Can cultural identity be elevated to a new theoretical value which would justify a new international set of rights and a new technological model? As we know, culture is reflected in values, norms, and practices. A person's particular cultural context, acts as a standard for perceiving, judging and evaluating experiences.

Theories Supporting Technology

Common Sense Theory: We present common sense theory as a theory of knowledge that is concerned about diverse matters centered on understanding, sense of proportion, and approach common to all. It is recognized that this quality is expandable provided when the expansion gains immediate general acceptance. Therefore, when we say that someone is exceptionally commonsensical, what we mean here is that he has more common sense than those of the others as evidenced by seeking of his advice on many matters: it is to say that he has more sense, and when he shares it, it becomes common at once (Agassi 1985). The commonsense theory can be made clearer when we explain in terms of science and technology. The most commonsense idea in both science and technology is

to seek quantitative functions and to deem them linear. The idea that there are numerical functions is often commonsensical: every common person, even with no scientific background or from an unscientific society will agree that given a simple and fairly constant fire and a simple container of water on it, the more water will take longer time to boil. On the whole, the idea of linearization is no more or less than the idea that any curve may be approximated by line segments and the shorter the segments the better the approximation. It is most significant to notice that most people who do not know the ideas expressed in the previous paragraph may come to know the meaning of it by applying a certain level of commonsense. That is also to suggest that there are truths which are not commonly held as true can be readily acceptable once they are grasped and become a part of commonsense belief. This kind of idea attains practical acceptability quicker than those which are scientifically sophisticated ones. There is a distinct tendency of technologists-especially those technocratically oriented- set out the other way and seek sophisticated ideas. The most famous reflections on science and technology were made by Aristotle. He considered science and technology as kinds of teachable knowledge looking for reasons on a general level (‘*know-why’*). But he drew some important discussions that are frequently repeated until today, giving them a kind of common sense status. Therefore it seems to be important to reconsider the original passages in the light of today’s science (Lenk, and Maring, 2001).

According to the distinction that was made by Aristotle, science (*episteme*) is about the unchangeable, while technology (*techne*) is about the changeable. There is no doubt that chemistry is about changeable things. In fact, substantial change, i.e., the change of chemical substances by chemical reaction is the very essence of chemistry. Understood thus, chemistry is a kind of technology. But we notice that the same is pertinent to high-energy physics, modern cosmology, biology, geology, and so on. In short, nearly all modern sciences are about changeable things and should be considered as technologies. Hence, this criterion seems to be not very useful. On the other hand Aristotle’s own science (*episteme*) of nature is also about changeable things in contrast to mathematics and his conception of ‘*technology’*, which are about the unchangeable. What is to be appropriated is the distinction between two types of objects which may solve the puzzle: while the empirical objects of nature are changeable, their principles of motion remain unchangeable. If we want to make sense of Aristotle’s distinction between science and technology, we have to turn our attention to the principles of motion of natural objects and artifacts (Lenk, and Maring, 2001).

Aristotle drew another distinction: Starting from sensations of concrete things, science finally aims at a generalized knowledge, whereas technology goes one step further and applies generalized knowledge back to concrete things. Aristotle’s final approach draws a distinction between different kinds of activity. Scientists look for theoretical knowledge (*theoria*) that is an activity having an end in itself and as such being a candidate for the highest form of happiness. Technicians, on the other hand, produce new things (*poiesis*), and such an activity has always an end in something else. In other words, the purpose of scientific activity is centered on just that activity itself, whereas poetical activity is always pointing towads the good for something else. Aristotle’s main distinctions between science and technology, though frequently repeated in various combinations until today fall short, because the structure of science has basically changed since the ancients. In sum, we may say that today’s science (1) is about changeable things, (2) is mostly experimental science, (3) follows a different methodology, and (4) is ‘big science’ in the sense of complex research cooperation based on the division of labor (Lenk, and Maring, 2001).

Truth Theory: Pragmatism is, first and foremost, a theory of truth. According to pragmatism, a true belief is always worth holding. It is a preposterous theory because pragmatism holds that the truth is only worthy of belief. Technology is by definition a means and pragmatic that many philosophers who view truth as problematic wish to view science as devoid of truth and to accomplish it by presenting science as identical with technology. This, of course, enhances the division of culture and civilization into art and science, since science is posited the same as technology. We can look at fine and applied art the same way and deny that there is such a thing as fine art since beauty is no less problematic than truth, and then both the arts and the sciences will be parts of technology (Agassi 1985). The word “*technology*” is used loosely in different contexts and it is not at all clear how it may be understood in general. Scientific fields are traditionally defined by textbooks. The traditional definitions are static and hence inadequate: they ignore changes that textbooks undergo from time to time. To improve upon this, one may view scientific field as the textbooks, which belong to a particular span of time added with the problems these textbooks give rise to those problems studied by researchers in this field, whose successful solutions are added to successive editions or variants of these texts. This improved definition is what is now called normal science in the terminology proposed by Thomas S. Kuhn. But fields of scientific inquiry, he observed correctly, undergo revolutions, and after the revolution normal problems are forged anew. Also, revolutions may create some new fields of science, or else destroy some other fields of science. It is hard to say when a field of science is transformed and replaced by another; but this is of little interest or significance. When we come to technology the picture is radically different. Whole fields of techniques, studies and developments of techniques, may become obsolete and give way to new ones. As for example, steamships and automobiles replace sailing ships and horse-drawn vehicles in a radical manner so that we normally take it that sailing ship technology is as obsolete as horse-drawn transportation, despite the continued existence of sailboats and of horseback riding (Agassi 1985). Technology as a mode of truth assumes the overall shape of Heidegger’s truth theory (Ihde 1979). Technology is a mode of revealing. Technology comes to presence in the realm where revealing and *unconcealment* take place, where *alethia*, truth, occurs. According to the Heideggerian vocabulary, revealing is a coming to presence within a framework. Already at this level, one can detect the emergent value given to praxis by Heidegger. In typical fashion, he reverts to etymological expositions upon Greek thought, which stands at the origin of our epoch of *Being*. *Techne*, Heidegger points out, is originally thought of as broader than ‘*technique’* in the contemporary sense. *Techne* is the name not only for the activities and skills of the craftsman, but also for the arts of the mind and the fine arts. *Techne* belongs to bringing forth to *poiesis*; it is something poetic. *Poiesis* is both making and bringing forth,

but bringing forth is presenting and thus is a *praxical* truth. Here is already the seed for the primacy of the *praxical*, which characterizes Heidegger's phenomenology; but at this point it is only important to see that *techne*, as with the ancients, is linked to episteme as a mode of truth as bringing to presence. *Techne* reveals or brings to presence something, which is possible. What has the essence of technology to do with revealing? The answer is: everything. For every bringing-forth is grounded in revealing (Ihde 1979).

But what is revealed? Technological revealing takes its particular shape from its field of possibilities and its framework. And its framework is a particular form of the human subject taking up a relation to a world through some existential intentionality. There is thus some particular presumed shape to world and some particular activity, which responds to that shape of the world. The world in its technological shape is the set of conditions, which Heidegger defines as world taken as standing reserve (*Bestand*). This is to say that the world, revealed technologically, is taken in a certain way, as a field of energy or power, which can be captured and stored. The revealing that rules in modern technology is a challenging, which puts to nature the unreasonable demand that it supplies energy. This makes world a field as standing-reserve. Such a view has certain consequences, for example, the earth now reveals itself as a coal mining area, the soil as a mineral deposit, which is to say that nature appears as a certain potential for human use. This is a variant upon how nature may be viewed. It stands in contrast to those civilization variants that, for instance, regard the earth as mother and to which one does not even put a plow. Thus one may say equivalently that the technologically viewed world is a variant upon civilization possibilities or that it is a historical transformation upon how nature is taken (Ihde 1979).

Heidegger argues that such an understanding of the world is a condition of the possibility for our taking up the kinds of technologies, which we actually develop now. He emphasizes the transformational features of this enterprise. Thus not only is it the case that the earth may be viewed as a resource, but what was previously taken as the dominance of nature over man becomes inverted so that man dominates nature through technology. "In the context of the interlocking processes pertaining to the orderly disposition of electrical energy, even the Rhine (a river in Southern Germany) appears to be something at our command; the river is dammed up into the power plant. What the river is now, namely a waterpower supplier, derives from the essence of the power station" (Ihde 1979). Technology, in this sense, is both the condition of the possibility of the shape of world in the contemporary sense, and the transformation of nature as it is taken into technology. The other dimension of Heidegger's response may be seen as an attempt to broaden and enrich technological revealing. And the enrichment, he sees, comes from a similar activity, which is in its own right *praxical* and poetic; the enrichment is to come through a basic revival of *techne* as art. It is rarely appreciated as the similar-dissimilar counter part of *techne*, but its mode of revealing opens new ways of "saying Being" as Heidegger puts it, thus is fundamentally different from *techne* as technology. What was art perhaps only for that brief but magnificent age? Why did art bear the modest name *techne*? Because it was a revealing that brought forth and made present and therefore belonged within *poiesis*. It was finally that revealing which holds complete sways in all the fine arts, in poetry, and in everything poetical that obtained *poiesis* as its proper name poetically dwells man upon this earth (Ihde 1979).

Epistemological theory: Technology does have an important epistemological aspect to its character and, furthermore, it is this epistemological dimension that is crucial to the philosophical placement of technology-related issues in the philosophical conversation. However, the standard account of epistemological issues has been formulated in such a way as to misdirect our approach to an understanding of the relation between science and technology. In particular, there are three mistaken assumptions about the epistemological relations between science and technology that have governed much of our thinking about these matters. These assumptions are: (Pitt 2000).

- A distinction between theoretical and applied knowledge, with science represented on the side of theoretical (pure) knowledge;
- A hierarchical account of knowledge, with "pure" scientific knowledge presented as superior to applied knowledge;
- Characterizing technology as applied knowledge, hence inferior to science.

The first of these, the venerable distinction between "pure" and "applied" with respect to knowledge and science and technology, has it that science is pure and technology is applied. However, it is very difficult to determine what is supposed to be pure or applied in either area. If the proposed answer is "*knowledge*", then the claim becomes "science is pure knowledge and technology is applied knowledge", and this is surely false, since, as we shall see, science is not pure knowledge as it claims. Likewise, if technology is supposed to be applied scientific knowledge, this view must be rejected for many technologies do not necessarily require prior grounding in the theoretical work of science. Without trying to define "*knowledge*", we can, nevertheless, agree that the product of science is knowledge. To see this requires invoking (rather than attacking) a different distinction, this time between the process whereby we produce knowledge and the product of the process (Pitt 2000).

The epistemological meaning of technology in scientific research has fully changed in recent decades. At the beginning, the classical relationship between science and technology established a subordination of the latter to the former. Thus technology was considered applied science, which helped the scientific process by manipulating the natural conditions of the scientific object. In fact, the influence of technology in search for scientific objectivity did not imply any important variation of the epistemological framework of scientific knowledge (Lenk, and Maring, 2001). We may have to accept that first of all, the influence of technology has become a determining ingredient of the epistemological constitution of scientific objects, for instance, in nuclear physics, cosmology, biochemistry, etc. The point is not that science uses technology as an instrument; this is indeed true, but it is a trivial remark. In fact, the present use of technology modifies the traditional relationship between the theoretical and the pragmatic goals of scientific reason. Given such an understanding, we could say that technology becomes an "*epistemological mediation*" of

science. It is not only an instrument required by the present complexity of scientific research, that is obviously true, but also the meaning of technology is not exhausted by saying so. Thus, it is necessary to point out that technology is an epistemological mediation. The difference between the two terms, instrument and mediation, is clear. An instrument means something that is used in order to obtain some specific results, and it is abandoned once these results have been reached, until the next time when it can be necessary to the goals of the scientific enterprise. We use this term to point out that the epistemological content of the scientific object is determined today to an important extent by the technological means to be used in any particular research project. In this sense, the epistemological content depends not only on theoretical conditions but also and especially on the technological requirements of the investigational process. This specific influence of technological means is nowadays a feature of the scientific enterprise whose epistemological relevance is evident. For this reason, *technification* can imply a turning point in the development of scientific knowledge, leading it to a pragmatic outlook through which it should deeply change many traditional features. It undergirds the idea that that scientific realism and the necessity of technological compatibility have now become technological realism. And this brings with it the predominance of pragmatic over theoretical truth in science (Lenk, and Maring, 2001).

Experimental theory: Experience in general is said to be a transaction, a process of doing and undergoing an active relation between an organism and its environment. According to Dewey, primary or immediate experience is non-cognitive in character. It contains "no division between act and material, subject and object, but contains them both in an unanalyzed-totality" (Dewey 1929). A subject as a sign possessing significance or meaning does not objectify what is experienced. Distinctions such as that between subject and object arise only for reflection. And a thing assumes or rather it is clothed with significance only as the result of a process of inquiry or thought. A fountain pen, for example, takes on significance for one in terms of its function or functions. And it does so as the result of a process of inquiry or thought. Therefore, as Dewey reserves the term "object of knowledge" for the term of this process, he can say that thought makes or constructs the objects of knowledge. On the other hand, Dewey is at pains to point out that his account of the activity of knowing does not entail the conclusion that things do not exist antecedently is being experienced or is being thought about. On the other hand, by identifying the object of knowledge with the term of inquiry, he is committed to saying that it is in some sense the product of thought. Dewey is concerned with the "transfer of experimental method from technical field of physical experience to the wider field of human life" (Dewey 1929:273). And such a transfer obviously requires a general theory of experimental method, while the use of the method implies direction by ideas and knowledge (Copleston 1996).

True, philosophy remains an activity. For thought is always an activity. But with Aristotle, for example, purely theoretical activity, the life of contemplation, is exalted above the practical life. And it becomes necessary to recall thought to its true function of being directed to resolving indeterminate or problematic situations by effecting changes in the environment and in man himself. Thought and practice have to be once more joined together. This union of thought and practice is seen most strikingly in the rise of modern science. In the early stages of history, man either tried to control the mysterious and threatening forces of Nature by magic or personified them and sought to appease them, though he also practiced simple acts such as that of agriculture. Later, as we have seen, there arose a divorce between theory and practice, which was effected by philosophy which has again provided an idea of man as spectator of modern science. For the scientist sees that it is only by correlating phenomena that we can understand the process of change and within limits, control it, bringing about the changes which we desire and preventing those which we regard as undesirable. Thought is thus no longer directed to a celestial sphere of unchanging being and truth; it is redirected to the experienced environment, though on a surer basis than it was in the early stages of humanity. And with the constant growth and progress of science, the whole attitude of man towards thought and knowledge has been altered. And this new attitude or vision of function of thought and knowledge needs to be reflected in our concept of philosophy, which can radically substantiate the idea that thought is always practical in some way, whether it takes place at the level of common sense or at the level of scientific theory.

Conclusion

The foregoing reflections adequately suggest that the present study is interdisciplinary in character. It consists of insights from different disciplines and draws its common legacy from a variety of *epistemological* approaches that are originated in the different philosophical schools of thought such as *pragmatism*, *analytical* philosophy, and phenomenology. Technology usually means the knowledge of tools, techniques, crafts, systems or methods of organization in order to solve problems. The human subject started to make use of technology with the conversion of natural resources into simple tools. Recent technological developments, including the printing press, the telephone, and the Internet, have lessened physical barriers to communication and allowed humans to interact freely on a global scale. However, not all technology has been used for peaceful purposes; the development of weapons of ever-increasing destructive power has progressed throughout history, from clubs to nuclear weapons. Philosophy of technology is a critical, reflective examination of the nature of technology as well as the effects and transformation of technologies upon human knowledge, activities, societies and environments (*Umwelt*). Techniques which were accompanied by "knowledge" embedded in mythology, where we might talk about myths as embryonic project designs. Practitioners either used natural tools for adaptation to the natural environment in an organic style of technology; or else they began the conscious introduction of newly devised tools as instruments for creating a new environment. The problem here is that there are two principal ways of reflection which appeared in the early cultures where one insisted on maintaining the existing natural and social order by way of specific practices (e.g., in ancient India) or ways of preserving harmony between society and nature; the other involved aggression against or attacking nature or the natural environment in the name of human society. But with the help of modern engineering practice and scientific technology, it has been transformed into a true "*design culture*". The theory would be based on this transition that came in stages: (i) engineering before the emergence of the engineering sciences, (ii) technology as applied science

and the beginnings of engineering sciences and (iii) the organization of modern engineering practice, including interdisciplinary research and systems engineering. The goal of philosophy of technology is to understand, evaluate and criticize the ways in which technologies reflect as well as change human life individually, socially and politically. The assumption underlying philosophy of technology is that the devices and substances we make and use, transforms our experience in ways that are rationally relevant. That is, technology not only enlarges and extends our capacities and effects of changes in the natural and social worlds but also does in ways that are interesting with respect to fundamental areas of philosophical inquiry. To sum up, technology poses unique practical and conceptual problems of epistemology, metaphysics, moral and political philosophy. The task for a philosophy of technology is to analyze the phenomenon of technology, its significance, and the ways that it mediates and transforms our experience in our everyday life.

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