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# A Critique of Technology and Science: An Issue of Philosophy

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**Abstract**

The purpose of this paper is threefold. The first is to investigate the relationship between technology and science. The second is to present an argument for the thesis that on the one hand science and technology benefit from philosophical criticism and on the other hand that philosophy requires reflection about technology in order to understand the essence of human beings as individuals and as members of the social community. The third is to highlight typical challenges, problems and questions about contemporary philosophy of technology.

## A Brief Outline of the History of Technology and Science

Humans use technical means to support their daily life, and they have been doing this since the early days of humans on earth. More than two million years ago, they were already using stones as primitive tools to prepare food, to hunt, to make daily life easier, and to draw pictures. Also from the beginning, humans have tried to improve and to optimize their facilites. Thus, progress in technology, i.e. progress in *know-how*, and a strong correlation between humans and technology, is observable from the very first days of human existence. The essence of a human being seems to be as a technician, a technology-producing craftsman, a tool-making animal (a phrase attributed to Benjamin Franklin), or a *homo faber*.

Also right from the beginning, humans have tried to seek knowledge about nature and the world of which they are part. More than two thousand years ago, they were already asking about the essential elements of nature. Thales of Miletus assumed that water was the primary element of the cosmos, Anaximenes believed it was the air, Anaximander claimed it was the immaterial *apeiron* (the infinite), and Democritus stated that atoms were the foundation of all natural phenomena. This means that science – in the sense of searching for *know-that* – was also there from the start.

However, there were no scientists in the modern sense at that time, because science and philosophy were originally the same thing. Thus, more than two thousand years ago, the philosopher was also a scientist and mathematician as well as profound thinker. Even in the 17th century, philosophy and science were still combined. So it is not surprisingly that in 1687, Isaac Newton published his famous laws of gravitation and dynamics in a book entitled *Philosophiae Naturalis Principia Mathematica*.

However, in the 18th century, science and philosophy started to diverge. Today, there are innumerable different sciences focussing on specific problems and questions. Thus, we have to use the notion of sciences in the plural, although there has been some noticeable convergence within the last few decades (to be discussed in the next Section).

Whereas philosophy and science were combined for more than two thousand years, it was not the same for technology and science. Both technology and science progressed in parallel with very little mutual exchange up to the 17th century. However, science then changed due to the application of experience and mathematics. From that time on, science and technology started to fertilize each other: science used technology to establish experiences, and technology used scientific results to create or improve technical products, and the notion of technology as *applied science* was born. Today, science and technology are inseparably connected, so one cannot exist without the other. This is valid at least for the relation of natural sciences and technology. In the case of human sciences and technology, there is also a connection, but it is not as strong.

It is worth noting that in the history of technology and science some theories seems to recur periodically. For example, in the 17th century, the theory of mechanism claimed that everything in the world could be explained mechanically. Indeed, through the use of experiments and mathematics, natural science became so important that topics outside natural science were also influenced by the field. Important examples are: in 1651 Thomas Hobbes discussed the (political) state – which he called the big *Leviathan* – in a mechanical manner; and in 1677 Benedictus de Spinoza used mathematical geometry to describe human affects or emotions and to develop his famous *Ethica Ordine Geometrico demonstrata*.

Then, in the 19th and the first decades of the 20th century, this point of view emerged once more under the notion of positivism (19th century) and neo-positivism or logical empiricism (early 20th century). These theories are based on the thesis that one single, uniform science, based on modern physics and mathematics, is completely sufficient to explain not only physical events but also human behaviour and incidents in history. For example, Hempel (1942) argues for general laws in history. This means that besides natural sciences, no specific human or cultural sciences are needed. Furthermore, these positions claimed that one uniform method of explanation is sufficient to explain all phenomena in natural as well as in human sciences, namely the causal deductive-nomological explanation, known as the DN-scheme of explanation. With respect to human behaviour and actions, these propositions yield the result that human behaviour can be adequately explained by physical language only (behaviourism), with no psychological or mental concepts such as desires, beliefs or intentions.

In the middle of the 20th century, the power of positivism and its successors decreased rapidly. However, at the end of 20th century, and even more strongly at the beginning of the 21st century, these points of view re-surfaced, now under the well-known notions such as naturalism, physical reductionism, physical monism, materialism, and eliminativism. As in mechanism, positivism and neo-positivism, the main source of the renaissance of these ‘modern’ positions has again been the great success of natural and applied sciences, this time neuroscience in particular.

The primary statement of neuroscience is that our brain is purely a natural object composed just of atoms and neurons. Hence everything in our brain is physically and causally determined. It is only an illusion that there is something like a mind, a soul, a will or even a free will. Hence, it is merely an illusion that people perform decisions and intentions and act from free will. There is no such thing as a will, since there are only brain processes based on physical, chemical and neuronal processes.

If this position is right, then there are many radical consequences. Two of them will be mentioned here. First, if all human actions are causally and unavoidably determined by the brain, then no one is responsible for their actions, because they could never act

otherwise. This means, if someone acts illegally, immorally or against existent laws, no judge is needed, but a doctor or a medical scientist, who locates the failure in the brain and repairs it. Thus, there is no need for jails, only for hospitals which specialize in brain defects. Secondly, if there is nothing more than physical brain processes, then all our desires, beliefs and intentions become physical epiphenomena or illusions, which is entirely in contrast to our self-concept or self-image as persons. In such a physical perspective, human beings are no longer individuals, persons or subjects. Instead they are purely physical and observable objects whose behaviour can be predicted and hence controlled. If the hypothesis of neuroscience turns out to be right in the drastic sense mentioned above, then persons will no longer exist.

What conclusions can be obtained from this brief historical review? The main one is that to be a human being is inseparably related to technology, as technology is an essential condition of human beings. Or in other words:

(1) Technology is a necessary condition or an essential constituent of human beings, i.e. technology is an anthropological constant, a *conditio humana*.

The same seems to be valid for science, too, provided science is considered (in the wide sense) as the systematical, methodical and reproducible search for knowledge or for *know-that*. However, the inherent force of human beings to achieve knowledge and to use technology is, of course, not the only essential, anthropological feature of humans. There are other even more important ones.

A second conclusion focuses on the relationship between technology and science. It has been shown that:

(2) Technology and science are inseparably connected. One cannot exist without the other.

And as a final conclusion:

(3) The influence of technology and science on human beings is enormous.

In particular in the 21st century, this influence of technology and science on human beings is going to reach a new quality or dimension. We now turn to this issue.

## Technology and Science in the 21st Century

It is remarkable that, since the beginning of technology and science, the speed of progress of both has increased instead of slowing down. However, it is not the quantitative change of speed but the change in the quality of progress which most requires philosophical reflection. The questions are: What kind of progress is this? Is the progress in technology and science in fact progress? To whom is it progress? What is progress, and what is not progress? And what does this progress mean for human beings? Since these questions have become evident in the 21st century in particular, a brief outline should been drawn of the development of technology and the science in this century, even though it is still in its early years.

In the 21st century, technology will influence the everyday life of humans in at least two essential ways: firstly, indirectly by new technological means, instruments or products; and secondly, directly by technological manipulations of humans themselves, e.g. by modification or manipulation of human minds and genes. And it is the second of these that we should consider in further detail.

Because the notion of manipulation has bad undertones, scientists and technicians prefer to talk about optimization or enhancement. Human enhancement is, of course, not a new idea. Doping in sport or even drinking coffee are types of human enhancement or human optimization. But with progress in science and technology, human enhancement will reach another level, even touching on the self-concept of humans. For instance, nano technology will offer the possibility of implementing very small, but very powerful nanochips directly into human brains to enhance their cognitive capability and their power to make decisions, to form intentions, to control emotions or to act adequately in specific circumstances. In addition, gene manipulation allows the optimisation of humans with regard to various medical diseases and to different skills, such as artistic, musical, and practical skills.

By applying these new, science-based technologies, the possibility of producing biological artefacts, or *biofacts*, with little or even without difference from natural human beings, become realistic. Of course, this sounds like science fiction, but it is already observable that the notion of *fiction* is going to vanish.

It is well known that nano-, neuron-, and gene-technology are the technologies with the most financial support from industry and public institutions in many countries. Technology and science in the 21st century is going to realize the possibility of human enhancement by gene manipulation and neuron enhancement. Biofacts are becoming possible. This means that:

- It is conceivable that the difference between natural and artificial will disappear.

Since the consequences and problems of this progress (if it is in fact progress) directly affect the self-perception and self-concept of human beings as human beings, they also fundamentally involve a primary topic of philosophy. Therefore, there is a need for philosophical reflection. The problems of producing biofacts are, of course, also ethical ones and hence represent also a philosophical challenge. They concern the claim of Aristotle (Physica), which seemed to be self-evident for more than two thousand years, in distinguishing between natural entities and artefacts: In natural entities the origin of motion and action is inherent, whereas this is not so in artefacts.

A second change in the quality of the progress of technology in the 21st century is a constantly diminishing difference between reality and virtuality. Cyberspace is the concept associated with this area of progress, though again we might ask if it is in fact progress. The prefix *cyber* is derived from classical Greek and is related to the notion of ‘control’. The various impacts of cyberspace on human beings are so drastic that a new subfield of philosophy called cyberphilosophy has been created to reflect on it.

In cyberspace, clients are offered the possibility of starting a new or second life in a virtual world. The technological goal of cyberspace is to connect the human mind directly with the computer or the internet. The result is that people get a new existence located entirely within a computer or the internet space. For instance, instead of sitting in front of the computer and playing games, cybertechnology offers people the opportunity to upload themselves fully inside the game. By doing this, they become part of the game itself, part of a virtual world.

Whereas the interface which connects the human mind with the computer is still the object of research, another cyberproduct called enhanced reality is already under construction. Games based on enhanced reality are usually outdoor games. In such games the players wear special cyberglasses through which they see the reality enhanced by virtuality. For example, they see real streets, cars and buildings in the city, where they are

walking around, but in addition they see, for example, wild and dangerous animals, which they have to capture. However, games are only one application. Today, we are still unable to imagine how cyberspace applications can change humans and their social life, but the following can already be claimed:

- It is conceivable that the distinction between reality and virtuality will vanish.

Up to the last century (and even today), individual sciences focussed on different objects of interest: Physics and more recently nano technology examined *atoms*, biology and bio technology were focussed on *genes*, information technology dealt with *bits*, and medicine and neuron technology were interested in *neurons*. However, the 21st century is going to bring radical change, because an essential feature of science and technology in the 21st century is their convergence. This is the third remarkable change in the progress of technology (and science). With the convergence of different sciences and technologies such as nano technology, information technology, bio technology and neuron technology, the fundamental entities of these sciences and technologies are being combined, involving the merging of atoms, bits, genes and neurons.

- Converging technologies and converging sciences, with implications on humans which cannot yet be imagined, will become an essential feature of the 21st century.

Whereas the 19th century was the industrial age and the 20th century was the information age or the age of the information society, the 21st century will become the age of converging technologies, converging sciences and converging fundamental entities, including atoms, bits, genes, and neurons. Simultaneously with this convergence, totally new effects and implications, in particularly on humans and society, will occur.

From this and the previous section it becomes evident that technology is not only a simple tool or an instrument, which can be used to ease everyday life for humans. Technology and science change the world and create specific images of our world. We will now proceed to consider these images of the world.

## Technology and Science as Images of the World

The image of science, in particular of natural science, is a causal and reductionist image. In this scientific image, the objects within our world are in a cause-effect relationship and follow causal laws. In a strong sense, this image states causality not only for physical objects, but also for organisms and humans. Since our brain is nothing more than atoms, neurons and other physical or chemical particles, this means that human thoughts, decisions, intentions, desires and beliefs can in principle be reduced to the physical level. Thus, in the scientific image, people are not individuals or subjects; rather they are objects composed of physical particles. Hence, there is no concept of the person in the scientific image of the world.

Similarly, the image of technology is restricted to objects which are observable and measurable. This observation may involve visual perception or measurement by means of tools such as microscopes, spectrum analysers or particles accelerators. Whereas the scientific image is a cause-effect image, the technological image is an end-mean image. It is an essential feature of modern technology that people are not only the originator of the desired ends or aims (in most cases artefacts), so they become ends itself. This means that, similar to the scientific image, people change from being a subject to being an object. The result is that people, who are now objects, can be optimized by technological means

similar to other objects or artefacts, for example by means of gene manipulation or neuron enhancement. In this case, the desired end is not merely a technological product developed to ease everyday life, but rather the optimization of the person himself.

Thus, in both the images – the scientific and the technological – humans objectify themselves. Jürgen Habermas talks about self-objectifying. This was originally located in the scientific (and technological) image, but it now increasingly touches on and influences the lifeworld or *Lebenswelt* (Habermas, 2005; Habermas, 2006) or the *manifest image* (Sellars, 1962). In the manifest image, persons are basically not objects compounded by particles; rather they are uncompounded individuals living in social communities and having individual as well as common intentions.

Both images are specific perspectives on the world, so they represent specific ways to experience the world. However, the popularity and success of both these images during the last two centuries have made us increasingly blind to alternate ways of experiencing our world. In Europe it was Martin Heidegger who first stated this inherent danger of technology (and science). His goal was to deduce the true essence of technology, and he claimed that the essence of technology is nothing technical. In the same sense, the essence of a tree is not a tree.

> "Technology is not the same as the essence of technology. If we search after the essence of a tree, then we must be aware, that the essence which penetrates each tree as a tree isn't a tree itself, i.e. a tree which can be found among the other trees." (Heidegger, 1962; translated by JHF).

This means that, in order to find out the essence of technology, we must go beyond technology. It requires something like metaphysics or metatechnology. Following this, technology is not simply a question of end-mean relation, which is a pure technical-based or object-based relation. The essence of technology is outside this technical sphere. This means that the essence of technology is not a material object or a technical or physical entity which we can touch. Technology in the sense of Heidegger is a world image, something non-material. In particular, it is an image which makes us forget that there are alternative and competing images to experience our world, such as hermeneutical, holistic, and religious images.

It is evident that both the images we are considering – technological and scientific – have an essential influence on humans as individuals and as members of social communities. In addition they have an impact on various other domains, including politics, economics, and public and private institutions.

- The images of technology and science influence the desires, decisions, intentions and actions of humans. They have the power to touch and even to damage the self-concept of human beings as humans.

For this reason, reflection on technology and science is essential for theoretical and practical philosophy, since reflection on the conditions, the meaning and the sense of a human being as an individual and a member of a social community is a key task of philosophy. This implies that enhancing our knowledge about the essence of humans requires us to reflect on the essence of technology. Or stated in a more radical phrase: Philosophy without technology is empty.

According to this, Vittorio Hösle claims correctly that technology is a key problem of philosophy (Hösle, 1995). Therefore, a key question is: How do technology and science influence our experience of the world, that is our view of the world, and how does it

impact on our desires, decisions, intentions and actions, and our self-concept as human beings?

- It is essential to philosophy to reflect on technology and science in order to understand the complex relationship between technology, science and humans. Reflection on technology and science is required to understand the concept of human beings.

As pointed out above, the images of technology and science are only two images among many. They are images generated by humans themselves. Hence, they in principle cannot be free of errors, and they cannot claim any final or absolute truth. Due to the success of technology and science during the last two centuries, this fact is frequently overlooked or ignored. The two are still the dominating images today.

Both technology and science form object-based and analytical images. Without doubt, both are particularly useful to explain specific details of our world. However, our world is more than an aggregate of details. It is a complex whole. To understand the world as a unique whole, natural science, causal explanations, and scientific analysis have proven not to be sufficient. At least hermeneutical and/or holistical considerations must be added.

What results can be extracted from the discussion so far? It has been pointed out that, on the one hand, technology is a condition of human nature, as it is inherent to human nature. On the other hand, it has been shown that technology has an enormous influence on humans. If uncontrolled, technology even has the power to put an end to the self-concept of human and, hence, to the existence of humans as humans. The influence of technology on humans can reach an extent where it can damage the self-concept of humans.

Technology is ambiguous in two senses: first, it is always combined with desired or intended effects on the one hand, and with undesired or unintended effects on the other hand; second, technology is, on the one hand, a condition or an anthropological constant of humans and, on the other hand, if uncontrolled, a possible cause of the entire elimination of the human race. These problems raises the question: What role do engineers play in this ‘dangerous game’?

## What Engineers are Doing

The most common view among engineers about their own professional actions is that they plan, develop, design and realize technological products by applying the results of science. In this sense, engineering is applied science. The products they create are based on the goals, desires and aims of the users or customers. Therefore, the principal task of engineering is simply to take into account the customers’ needs and to find the appropriate technical means to accommodate these needs. The standard notion for this is the *end-mean relation*. Thus, in the view of engineers the following claims are valid:

- Technology tries to find appropriate means for given ends or desires.
- Technology is applied science, i.e. it is the transformation of nomological cause-effect relations into end-mean relations. It is the transformation of epistemical *know-that* or *know-why* into practical or instrumental *know-how*.
- Technology is the aggregate of all technological artefacts.

- Technology is the total of all actions and institutions required to create artefacts or products and the total of all actions which make use of these artefacts or products.

In this technological sense, engineers appear as good friends who help to satisfy customers' needs. Therefore, from the moral point of view, their actions seem to be inherently good. The engineer appears to be a moral hero. The notion *engineers as moral heroes* is the translated title of an essay in German by Kenneth D. Alpern (Alpern, 1993).

Despite these good actions in delivering products desired by customers, all other activities of engineers are morally neutral or value-neutral, because to find adequate means is merely a task of applying scientific results. These results can be right or wrong, but not good or bad. Applied science is regarded as an automatic or determined process, which is merely regulated by the laws of nature, for example by physical laws, rather than moral rules. Of course, customers can use technical products in a way not intended by engineers. They can use, for example, a well-designed hammer that was designed to knock in nails to kill another person. But for this action the customer is responsible, not the engineer. Kenneth D. Alpern compares engineers with magicians:

> "When people feel alone, then engineers invent telephones, cars and aeroplanes to bring them together. When people are hungry, then engineers produce harvesters, fertilisers and pesticides, to provide them food. When people lack comfort, then engineers develop heaters, air conditioners and foams, to supply them with comfort. When people are bored, then engineers invent cinemas, televisions and video games, to entertain them. In short: Whenever people have a problem, engineers will solve it." (Alpern, 1993; translated by JHF).

Dazzled by the success of technology, the following slogan is also well known among engineers: The possible we produce directly, the impossible takes somewhat longer.

The viewpoint of engineers – briefly depicted in this section with regard to the question about what engineers are doing – is purely technological and also idealistic. It is a viewpoint which is still very common today, at the beginning of the 21st century. However, it is a viewpoint with flaws. It must of course taken be granted that the given simplified view of engineers with regard to technology has taken a turn within the last few decades. This turn is observable in many technical universities, where inter-disciplinary courses in technology assessment, philosophy of technology, philosophy of science, and general and applied ethics are already inherent parts of the curriculum.

We should also note the following: Both *know-that* as well as *know-how* as used above are types of knowledge. "*Episteme* focuses attention on the *truth* of what is know; with *techne*, the focus is on efficiency. The first concerns *pure knowledge*; the second, *knowledge of doing or making*." (Agazzi, 2001). Or as Cordero correctly pointed out, "One primary internal aim of science is the acquisition of knowledge and understanding the world. Rarely, if ever, does a technology have that as its *primary* aim [...] the basic internal aim is generally something else." (Cordero, 2001). Know-how, is "knowledge of resources and methods, how to do things." (Cordero, 2001).

## Errors in the Technological Debate

Today, it is well known that technology does not only result in desired and intended effects, i.e. in effects for which technological products are created. They also result in undesired and unintended effects. The impact of unintended results or effects – surely the most critical one today is increasing environmental pollution – damage the idealistic

image of engineers portrayed in the previous section. In fact, it is an image with basic errors. In this section some typical errors of the technical debate are presented and briefly discussed (Franz, 2007). The first one is:

(i) Technology is purely an instrument to achieve or satisfy customers' demands. It follows a simple end-mean relation.

In the last century, it was common (at least among engineers) to state that technology was an instrument or a means to satisfy the customers' ends or demands. However, this is no longer valid in the 21st century.

Today, technology exhibits an inherent dynamic, so it has become a process with its own internal dynamics. This process results in multiple means and subsequently in a wide range of technological products which no longer just meet customers needs. Thus, contemporary technology no longer follows a simple end-mean relation. Instead it follows an inverted end-mean relation. In fact, it follows a mean-end relation.

The end-mean relation is inverted in the sense that customers or clients must now be convinced to be in need of the new technological artefacts or products. Or more drastically formulated: The customers must be manipulated to buy these new technological products which they have not needed up until now. And this is the task of advertising, supported by up-to-date media or multimedia technology. The strategy is always the same, namely to demonstrate that the new technological products are indispensable.

The task of advertising or sales promotion is to change the position position from "I don't need this" to "I need this". The way it is done is well known. The arguments of advertising are as follows: If you don't purchase it, you will look older than others, you won't be as beautiful as others, you are old-fashioned, you are less dynamic than others, and so on.

What does it mean? It means that the customer is no longer the main beneficiary of technology. Instead, business comes first. Technology and science are under pressure from commercialisation and business. In this inverted system, the customer himself becomes a means or a resource, i.e. an object. He becomes simply a parameter in the cost- and economy-oriented calculations.

The second error is:

(ii) The actions of engineers and technicians are automatic and pre-determined, because they are exclusively governed by the results of science, in particular by the laws of nature discovered by science, such as physical laws. Hence, technology is nothing more than applied science.

Many professional engineers claim that engineering follows a causal chain starting with scientific results and moving through the technological means to the technologically optimized ends for customers. For this reason, any engineer's activity is completely automatic and hence pre-determined. Engineering is straightforward.

This proposition is wrong, because there are at least two nodes of unavoidable decisions in the process between scientific results and end-products. First, there is normally not only one specific method to reach a desired end, but rather there are usually different technological means to achieve the same end. Second, the desired end can be optimized in different ways. It can be optimized with respect to functionality, efficiency, economy, profitability, safety, environmental protection, energy consumption, health issues and many more. Often, these options of optimization are inconsistent, as one optimization excludes the others.

In both nodes – choosing the means and choosing the kind of optimization – engineers have to make a decision influenced by many parameters, in particular non-physical and non-technological parameters. Considering the process of decision in more detail, two implications can be deduced. First, decisions require criteria, such as values grounded in moral rules and social commitments. Second, decisions are not only right or wrong, as they are first of all good or bad. In this sense, engineers can be asked: Why did you decide in this way and not in that way? Why did you choose this method instead of that method to reach the end? On which criteria or values did you ground your decision? By asking these questions, the engineers are required to give a *response*, so they are *responsible* for their decisions and their subsequent actions. Their response must be based on reasons, instead of causes, because the response is outside the sphere of science and outside the sphere of applied science.

If, for example, a car is be optimized, then this can be done with respect to security, functionality, convenience, stability, cost effectiveness, energy consumption, speed, environmental protection, and many other criteria. It is evident that not all of these parameters or criteria can be optimized simultaneously. Some of them are conflicting. This begs the question: Which criteria should be used to select the type of optimization?

This means, the first-order criterion of optimization requires a second-order criterion, which finally yields an infinite regress or at least the question: Which final or fundamental criterion breaks this regress? Without doubt, this final criterion is outside any technological and scientific sphere.

The third error is:

(iii) The field of technology is moral neutral or value neutral.

Even today many engineers claim that they are working in a moral and value neutral field, because it is a field which is governed only by technological decisions which in turn are governed by physical laws of nature. Since these scientific laws are inherently neutral to morality and values, the same applies to technology.

However, this viewpoint is also wrong. The argument to verify this error can follow the same line as just given above: Engineering is not a simple straightforward process depending only on technological aspects. Instead it is a process with various points at which decisions must be made, requiring consideration of both technological *and* non-technological aspects, in particular non-technological criteria, such as moral rules and values. In addition, it is evident that engineers and technicians have to perform actions in order to solve their technological tasks. Hence, just like the everyday actions of ordinary people, the actions of engineers and technicians have to be judged as morally good or morally bad.

Therefore, engineers and technicians (and also scientists) are morally responsible for their technological actions in the same sense as ordinary citizens are morally accountable for their everyday actions. In fact, they are even more morally accountable than ordinary persons, because they are much more aware of the problems of new technological artefacts, since they have actually designed and produced them.

The conclusion is that technology should always be in touch with questions of criteria, morality and values. Hence, decisions and subsequent actions performed by engineers, technicians and scientists are not exclusively technical-based. Technology and science are in need of ethical reflection.

*Ethics of technology* is an already well-established sub-domain of philosophy of technology and of ethics in general. However, it is not discussed in this paper, which is

primarily focussed on the metaphysical aspects of technology and on the relationship between philosophy, technology and science.

The fourth error is:

(iv) The responsibility of the use of technical products is limited to the customer only.

Of course, no car-designing engineer is responsible, for instance, when the owner of a car intentionally kills another person by running them over. On the other hand, the main task of engineers is to lower the risk of technological products with respect to any undesired effects, particularly the undesired effects on users, society and the environment. Since engineers know their products much better than anyone else, their task is to estimate the undesired effects and to tell society about these effects and risks.

Therefore, in addition to technological know how, engineers should have the ability to estimate the effects of new technologies – the desired effects and also the undesired and unintended effects – and the ability to evaluate these effects. In addition, they should be aware of the fact that to assess or evaluate the effects of technology is outside the scope of technology and applied science. They should know that this sphere is based on and influenced by various criteria and values which normally are inconsistent. It is the sphere or scope of reasons, not the scope of causes.

The fifth error is:

(v-a) Technological problems can always be solved by technology.

A stronger statement of this error is:

(v-b) All problems (not only technological ones) can be solved by technological means.

This statement must be revised, because it implies an infinite regress. The reason is that each technology is ambiguous, since each technology has desired and undesired effects. If the problems of undesired effects are solved by technological means, than this again results in desired and undesired effects and so on. To cut this regress requires solutions based on social, political or other non-technological decisions.

The sixth error is:

(vi) Technology is the aggregate of all technological artefacts and the total of all technological actions performed by engineers and technicians.

This statement treats technology as an island which is not connected to the rest of the world. It ignores the fact that technology is inseparably connected to human beings as individuals and as members of society; and it ignores the fact that technology is inseparably combined with morality, values, non-technological criteria and responsibility.

As pointed out above, the essence of technology is not something technological, rather it is something intangible. Technology changes the world, influences human desires, decisions, intentions and actions as well as the view of the world. For this reason, it is a task of philosophy to consider technology (and science) critically, in order to indicate errors and misunderstandings in the technical debate. It is a task of the philosophy of technology to point out the true meaning of the notion of technology, to argue for the essential connection of technology (and science) with humans, and to highlight the inherent ambiguity of technology. By doing this, technology (and science) can benefit from philosophy, because it offers a new perspective on technology (and science) which goes far beyond the simple technological- and pure material-based viewpoint.

In this sense, a critique of technology (and science) widens the view on technology (and science). In this sense, it does not impede the progress of technology (and science);

rather it offers the opportunity to change this progress from progress of technology (and science) to progress for mankind and the world.

In conclusion:

- Philosophical reflection and criticism is unavoidable for technology and science.

Or more drastically expressed:

- Technology without philosophy is blind.

In order to avoid misunderstandings, a final remark on the notion of critique is appropriate. What is critique? In most languages it usually means to say this is bad, that is useless and so on. Thus, in everyday speech the notion of critique is often associated with negativity. However, this is not the same in philosophy. In philosophy the concept of critique is usually understood in the sense of Immanuel Kant. critique in his sense means to consider something systematically, so that nothing is neglected, to ask beyond and to reflect the conditions. In this sense Immanuel Kant uses the concept of critique in his famous trilogy *Critique of Pure Reason*, *Critique of judgment*, and *Critique of practical reason*. This means, critique is first of all a method. However, this doesn't exclude the fact that, secondly, critique includes evaluation as well, based on traceable arguments and on reflections of the criteria and conditions of the evaluation.

## Summary and Outlook

The main purpose of the philosophy of technology is to reflect on technology and on technological development.

First, this purpose includes reflection on the ontological question: What is technology? By answering this question one must be careful not to be hasty and restrict the answer to technological artefacts or physical entities, as pointed out above. The essence of technology is intangible.

Second, this purpose involves the study of the relationship between technology and humans. It has been pointed out that technology is a constituent or condition of humans, so it is an anthropological constant. Hence, technology is not contingent or accidental to humans, it is necessary to them. It has also been shown that technology does not merely change our world, but it also changes our view and our experience of the world. Technology influences desires, decisions, intentions and subsequent actions of both individuals and groups. And it impacts on politics, private and public institutions, cultural life and so on. Because of this, reflection on technology is a key task and an unavoidable issue of philosophy, provided that the knowledge of the essence of humans is a primary focus of philosophy. In this case, the previous claim can be paraphrased more drastically:

1. Philosophy without technology is empty.

On the other hand, scientists, engineers and technicians have to be enlightened about the essential feature of technology depicted in this paper. They should be taught about the true meaning of technology. Because of the great influence of technology on all fields of human life and on humans themselves, technology requires criticism. Again, this is a primary task of philosophy. By fulfilling this task, both science and technology benefit from philosophy. Or again more drastically claimed:

2. Technology without philosophy is blind.

The resulting claim *philosophy without technology is empty; technology without philosophy is blind* is a deliberate allusion to the well known claim by Immanuel Kant: *thoughts without content are empty, intuitions without concepts are blind*.

Scientists, engineers and technicians who are aware of the background and the essence of technology will be able to experience technology from another perspective than a mere technological one. It is a perspective based on reasons and values instead of causes and effects only.

In the 21st century, scientists, engineers and technicians are challenged to widen their view on technology in order to develop human- and nature-oriented technological products. Humans are subjects not objects, and nature is a partner not an object.

In order to understand the complexity of technology, which goes far beyond technology itself, many technical universities have already started to include philosophical and interdisciplinary courses in their curricula. To find solutions in the field of technology is not simply a technological task, it is an interdisciplinary and cross-cultural task. Technology is not an island isolated from the rest of the world. Technology is an inherent part of the world with interactions with all other parts of the world. Because of these interrelationships, it is impossible to estimate all unintended impacts of technology. It is even impossible to estimate all implications of the intended effects.

Technology and natural sciences consider and explain our world from an analytical, causal and nomological perspective. Because of their success during the last two centuries, we are today often dazzled and may think that this perspective is the only one to consider in our world. But is it really the only perspective from which to consider the world? Surely not. There are not only alternative perspectives outside science and technology, there are options in the scientific field itself, for example to understand the world rather than to explain it.

Understanding the world means searching for the sense of the world. This gives rise to the question: What prevents us changing our perspective, for example moving from a mere causal, nomological perspective to a hermeneutical or holistic perspective, which considers the world as a whole and may give us new insights into our world?

However, we should not forget: It is essential to humans that our knowledge is inherently limited. We are part of the world and part of the universe in which everything is related and in which everything has its own sense. We are unable to gain an overview of this, since we are inside the world, not outside it, even when we are travelling in space.

Our knowledge is limited and will remain limited. This is valid for all perspectives from which we experience our world.

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