PHILOSOPHY AND ENGINEERING

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Abstract: The divorce of technical education from philosophy and humanism leads to the loss of critical thinking and the edification of the one-dimensional man. My article aims to indicate the main points of connection between these two spheres and to outline the fertile, organic way in which the work of the engineer could be integrated in a value-oriented approach and put in the service of humanity.

Keywords: philosophy; engineering; critical thinking; one-dimensional; technological rationality.

1. Introduction

The pressures exerted by the economic system on the labour market and on our higher technical education system have led to the divorce of engineering by one of its most fertile partners, philosophy. The fact that the consumer economy has come to consume its own consumers is one of the bitter ironies of the postmodern society. The disappearance of philosophy and critical thinking, as one of its favourite tools, from academia is one of the effects of the mentioned divorce and is a symptom that should worry those responsible for the destinies of the future engineers. I do not intend to make an indictment here. My intention is to show what technical education would gain by establishing a durable connection with the philosophical thinking. We will proceed systematically and examine one by one each of the well-known branches of philosophical reflection.

2. Ontology

Ontology is the fruit of grounding thought, a kind of thinking that comes out of itself and raises the question of the ultimate basis of reality. Ontology asks about the foundations of existence, not taking it for granted. In other words, ontology is the reflection that comes out of the daily slider crank mechanism to reflect on its movement, cause and purpose. With the help of ontology, we can escape the system we're in and place ourselves beyond it but in its perspective, judging its way of being. There is no more comprehensive approach than the ontology offers us because beyond the being there is only nothing.

Ontology is the embodiment of the original metaphysical thinking that implies the wonder of which Aristotle speaks about as the beginning of the philosophy. It is the irrepressible need to provide an answer to the questions "why" and "how". With it was born an entire culture, the Western culture, and from it derives the most advanced knowledge of our species, the scientific knowledge.

But what's the use for an engineer to acquire an ontological perspective? First of all, this perspective has an ordering function and is thus clarifying. By proceeding categorically, ontological thinking offers us a means to order the diversity of the world according to essential characteristics. Therefore, it has a prominent structural and reductive character. Furthermore, ontology refers us to the principles underlying the systems by capturing the determinism of systems, their legitimacy and causal relationships.

In the case of engineering, the understanding of systems, the ability to mentally represent them and to grasp their functioning is the premise of any innovative idea. To see the whole transparent in its action, to comprehend it and to penetrate its relations is the result of a mind acquainted with the rarefied air of the philosophical abstraction characteristic of ontology.

Therefore, the ontological perspective is comprehensive, categorical, orderly, analytical and reductive. Combined with a counterfactual approach, it represents the fundamental ingredient for the technical creativity translated in the form of inventions or innovations. Nikola Tesla could not have invented the electric motor, the radio, the Tesla coil and much more without an ontological perspective and without wondering why things should be as they are and how they could be conceived in alternative ways. We notice that today repetitive and non-innovative work is gradually taken over by artificial intelligence. Creativity will make the difference in engineering as well.

3. Logic

Logic is a fundamental acquisition for anyone who aspires to ensure the formal correctness of his thinking. Without ordering the judgments and arguments in reasonings and without securing their logical validity, not even the minimum conditions for attaining the truth can be met. Logic represents for rational thinking what mathematics represents for the sciences. Logic is "the study of winning strategies in the game of legitimate argumentation and inference; it is concerned with the possible means of proving the sentences " (Flew 1996, p. 208). Both deductive and inductive logic (the Aristotelian logic developed by the Stagirit in his *Organon*) are essential parts in any attempt to establish the truth of our reasonings. Logic provides the rules with the help of which we can make valid reasonings showing the dangers to which we are subjected if we do not follow them (serious errors such as self-contradictions, paradoxes, paralogisms, etc.).

Logic is a formal discipline; it ignores the content of the sentences forming the inferences. As such, logic represents the condition of possibility of any thinking and thus the fundamental requirement of truth. Any rational enterprise presupposes and takes for granted the logical skeleton of its thinking, but engineers have in addition to gain from here the possibility of translating this acquisition into the mechanisms and devices they imagine. Thus, logic offers to the one who studies it rigor, validity, clarity, precision and systematicity.

One of the applications of logic in the engineering sciences is digital logic used in the analysis and design of digital systems, computer programs and electronic devices. It uses Boolean functions and operations, logical connectors (negation, conjunction, disjunction, implication, equivalence, incompatibility), expressions in propositional calculus (predicate, quantifiers), axioms, sentences and values of truth. The creator of this mathematical logic was the English logician and philosopher George Boole. His mathematical logic is the basis of computer science and made possible the creation of the computer. The domain created by Boole is of crucial importance in the theory of electronic circuits.

4. Gnoseology and Epistemology

A significant part of philosophy's labours has been dedicated to the concept of knowledge. Efforts have been directed towards researching the sources and forms of knowledge and also its extent, limits and foundation. The approach by which knowledge takes itself as an object in order to explore its nature, limits and possibilities is a natural one. This self-reflexivity is a necessary step because otherwise how one can claim that one can research and know the physical reality (and how one can innovate, in the case of engineers) if one does not answer the simple question: what is knowledge?

Regarding the concept of knowledge, we can make the same statement as Augustine regarding the concept of time: "What then is time? If no one asks me, I know what it is. If I wish to explain it to him who asks, I do not know" (Sf. Augustin 2018, p. 557). The concept of knowledge has the same categorical vagueness and this is all the more problematic as the claim of possession of knowledge seems today a right that you possess by the simple fact of being born human. In other words, people are convinced that they hold the truth, but they can't even answer the question of what it means to know and what the truth means. Knowing knowledge is therefore the first step in trying to understand anything in this world. Gnoseology offers us the criterion to distinguish between objective knowledge and appearance or impression.

In Plato's dialogue Theaetetus we find one of the first outlines of knowledge. For Plato knowledge is true judgement accompanied by Logos, that is, by arguments. Thus, a simple opinion can become knowledge with objective significance. Insofar as its truth can be grounded, it can become objective knowledge unanimously accepted. The process of knowledge can be conceived as an evolutionary and cumulative process that brings together two components:

> "on the one hand, avoiding and eliminating error, on the other hand, gaining as much truth as possible, especially truths that have as rich an informative content as possible, with as much explanatory value as possible. These two requirements can often lead us in different directions. Indeed, the most handy strategy to minimize the risk of error is to make judgments with as little informative content as possible. The less we believe and assert about real states, the lower the risk of making a mistake. By adopting a strategy that satisfies only this requirement, we will not move towards achieving the goal of knowledge. For this we will have to look for and find a reasonable compromise between the two requirements" (Flonta 1994, p. 32).

If we analyse all our ideas and beliefs, we will notice that in fact very few meet cumulatively these two conditions: to be true and us being able to justify their truth, that is, to ground them. We can also understand why new knowledge is so difficult to acquire and why much of what is published in books, scientific journals, doctoral theses does not really represent an advance in knowledge (obtaining valuable knowledge with a high degree of informativeness), but only systematizations of the existing knowledge accompanied by non-innovative comments, syntheses of data with low degree of relevance, predictable diagnoses and truisms dressed in scholarly clothes. He who embarks on the path of knowledge is like the explorer who ventures into unknown territories where the risk of failure is considerable. Most of the academic work is one that does not even pose the problem of such a risk. It is like a walk in the park on beaten tracks and paved alleys. Only bold conjectures with a high degree of risk and likely to be falsified in the Popperian sense represent a real advance of knowledge.

Epistemology, on the other hand, is a philosophical approach that takes as its object the most privileged type of knowledge having the highest degree of trust, namely the scientific knowledge. At the heart of the epistemological approach are concepts such as scientific theory, lawfulness, explanation, prediction, scientific hypothesis, validation, corroboration, falsification, evolution and revolution in science. In this case too we place ourselves inside a metadiscourse, an inquiry that focuses on the superlative cognitive approach that our species is capable of. Determining the fabric of science, distinguishing scientific knowledge from common knowledge and especially from treacherous pseudoscience, clarifying the crucial function that theory plays in science, understanding the mechanisms of science and how science evolves cumulatively represents the theoretical primer of any man who places his life on the horizon of science. Therefore, of any engineer.

There is an opinion that engineers are technology people and not science people, that scientific research is too high a horizon for their work and that their concern is to answer the question "how to" and not "why". Such an opinion transformed into a mentality would have extremely detrimental effects on the education of engineers. Severing engineering from science, its great homeland, would lead to transforming engineers into technicians and would obscure the fertile relationship between understanding the nature and transforming it for the benefit of man. Breaking the chain of knowledge would be equivalent to transforming man into a tool, indeed a sophisticated one in the case of engineers. Narrow specialization is the elegant and nonderogatory name for ignoring the foundations of scientific knowledge. Therefore, gnoseology and epistemology provide engineers with comprehension, theoretical depth, global vision and horizon of innovation.

5. Ethics

Ethical issues have never ceased to be actual in the history of mankind. Human existence in communities raises more difficult issues than those related to knowledge (science) and those associated with adaptation to the environment (technology). For animals living in groups these problems are solved based on considerations related to physical strength and status within the group. We can’t talk about a rationalization of suffering, therefore injustice in the human sense does not exist here. Ordeal is perceived as fate.

Ethics started in Socrates' Athens as an attempt to provide a universal basis for good, justice and virtue. Since social justice was mediated and confirmed by political power, the interest in good deeds and fair individual behaviour was accompanied by the preoccupation with designing the optimal political regime. However, Socrates was aware that personal choice is beyond the law. The law is just a human convention as, for example, money is a useful convention to facilitate the exchange of goods. But ethics cannot be grounded in human conventions. The relationship should be the other way around: laws emerge from morality, and the latter is based on universal values. The power of ethics lies precisely in this transcendence of laws, political regimes, local customs and even history. This does not mean, of course, that a rational foundation of ethics is unproblematic or that ethical dilemmas are easy to solve.

Engineering does not lack such dilemmas either. We like to imagine that engineers work for the benefit of all. But how many of the engineering achievements do not have a destructive or harmful potential for humans, animals and even for the entire planet? To what extent those who work to create and improve such things have an ethical responsibility? What kind of ethical attitude should adopt an engineer hired for a substantial salary to develop a chemical weapon or a highly advanced surveillance system?

If science and fundamental knowledge cannot be employed ideologically without being automatically invalidated, instead technology can be ideologically subsumed and diverted from its noble goal, that of improving the human life. Therefore dividing engineering from the valorising element represents a blind advance on steep peaks. Ethics provides the engineer with values, moral intuition, humanism, knowledge of good and evil, non-conjunctural foundation of one's own action.

6. Aesthetics

Understood as a conceptualisation of beauty with its categories, aesthetics seems the furthest philosophical domain in relation to engineering. Some will say that artists are the legitimate doers of beauty, the ones entitled to perform it on a human scale. This is wrong. The need for beauty is deeply rooted in the human soul. Art gives us its share of beauty, a spiritualized one, often cryptic and therefore undemocratic. But even the most uninformed man feels the irrepressible need for beauty. The beautiful shapes of the devices, their harmonious colours, the symmetrical lines of the vehicles or buildings are just a few examples of the kind of beauty that the engineer, the designer, the architect mediates to us.

There is another consideration for which engineers must pay attention to beauty. There is a connection between harmony and functionality that is often ignored. This relationship found in nature and the evolution of the living world has created a balanced and well-proportioned repertoire of functionality. The golden ratio corresponding to the Fibonacci numbers can be found in the proportions of the human body, in the dentition of man, in the shell of the snail, in the shape of the sea waves, in the structure of some crystals, in the sunflower, etc. It has also a correspondent in art. Many of the engineering inventions and innovations are built on this proportion that a keen eye can find in the harmony of the shapes. Henri Coandă used the golden ratio to build the wing profile of his jet plane, which proved to be the best constructive solution. Therefore, the concern for beauty and balance, together with the careful observation of nature can be sources of inspiration and practical solutions for inventors and engineers.

7. Conclusions

Conjunctural pragmatism, narrow specialization and mass education lead to the edification of the one-dimensional man. The German philosopher Herbert Marcuse warned that the hegemony of technological rationality represents the symptom of an industrial society centred on consumerism as a form of social control, one in which happiness is commodified. Losing his critical thinking and, with it, his freedom man becomes a simple tool in the economic machinery (Marcuse 1977). I will add that the divorce of the technical training from humanism and philosophy, the promotion of procedural knowledge to the detriment of theoretical knowledge, the massification of education only fuels the system described by Marcuse. Engineering is not an activity in itself and is not made for its own benefit. It must always be a servant of the people.

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