Journal of Multidisciplinary Engineering Science and Technology (JMEST)
ISSN: 2458-9403
Vol. 4 Issue 1, January - 2017

On The Epistemological Basis of Engineering Knowledge

Víctor Alcántara Alza[1]
[1]Post- Graduate school, Trujillo National University, campus: Juan Pablo II s /n Trujillo-Perú
E-mail: victoralc_unt@hotmail.com

***Abstract*—Although, today engineering is considered as clearly distinct from science, scientists components in the education of engineers contribute to convey the idea that engineering is essentially little more than the application of the exact sciences and natural to the reality of practice. To say that engineering is applied science involves only assume that engineering products are only applications of scientific knowledge without any significant contribution to the intellectual or creative order by engineers.**

To help challenge this view and contribute to a reflection on what knowledge is created in the engineering and to establish its distinction of knowledge of basic science on which it is based, is proposed to make an analysis of the epistemological foundations that investigations are based on the field of Engineering, establishing his method, in order to illuminate some of the typical and distinctive attributes of this new type of knowledge based on modern technology.

To help challenge this view and contribute to a reflection on what knowledge is created in the engineering and to establish its distinction of knowledge of basic science on which it is based, is proposed to make an analysis of the epistemological foundations that investigations are based on the field of Engineering, establishing his method, in order to illuminate some of the typical and distinctive attributes of this new type of knowledge based on modern technology.

In our times, the diversification of the branches of engineering, grows exponentially, including those born with the informatic revolution, giving rise to the definition of Engineering evolve in the same way. The result is that many epistemologists have come to the conclusion that the engineering of the modern world is more than applied science.

The possibility to raise an epistemology in Engineering is based on empirical evidence show that the technology is knowledge. If technology is knowledge. What kind of knowledge is and how it is situated in the general field of human knowledge?

Keywords—Epistemology,Science, Engineering, Technology, Knowledge

I. INTRODUCTION

The traditional distinction between pure and applied sciences was collected by Mario Bunge in the 60s of last century [1], and revised versions by Mitcham and Mackey, 1972, and Rapp, in 1974 [2, 3]. In his article, Bunge made the proposal to understand engineering as a specific kind of applied science.

Bunge explains that is not orientation to satisfying needs that makes the difference between pure and applied science, "but the boundary should be drawn between the researcher looking for a new law of nature and the researcher who applies the known laws to the design of a useful thing."While the former wants to understand things better, the latter want to improve our mastery of them. This makes it clear that the engineer is aiming for practical purposes, while the cognitive scientist seeks knowledge. This definition of Bunge on Engineering has been and remains as a paradigm to date. The thesis holds this Article is that engineering is more than applied science.

The Bunge proposal does not exclude that engineering sciences making use of idealizations or theoretical concepts, otherwise they would not be able to predict objectives resulting from the application of technology. But these predictions do not work as evidence of the theories in question, the idea behind them is to "find what to do in order to carry out, prevent or simply change the rhythm of events in the course of a pre assigned mode". Therefore engineering as an applied science cannot consist in the application of pure science. Applied sciences have their own goals and therefore their own methods.

Though engineer can apply concepts derived from science, also applies other that are unique to their discipline and do not exist in science or are used differently. For an engineer, knowledge is not an end in itself but only a means to achieve its objectives always linked with the design, construction and operation of objects and artifacts.

Many researchers [4, 5, 6], agree that knowledge engineering is more than applied science: it has different purposes, use different methods to produce knowledge, very different with different results. However, the work in this area tends to remain at the level of conjecture about the rather superficial differences in the content of the disciplines.

Today most epistemologists claim that an engineer is a technologist, but not always a technologist is an

engineer, and almost everyone agrees that Engineering is the highest expression of modern technology. Thus, we find the epistemological foundations of knowledge in engineering involve seeking the possibility of an epistemology in the same technology.

II. POSSIBILITY OF EPISTEMOLOGY IN TECHNOLOGY

The need to establish an epistemology in technology is based on empirical evidence would demonstrate that technology is knowledge. If technology is knowledge, then their activities fall in epistemology. The test provides Hugo Padilla who argues the existence of a knowledge obtained by generalizations, born, in turn, the practical resolution of technological problems; coming to the conclusion: "It is possible to acquire knowledge from a generalization of the functions and creation of technology " [7].

There upon, if the technology is knowledge, is involved in the problems of epistemology, so it is necessary to study how information technology contributes to science. We anticipate that its relations with science are, at least, the following: verification of scientific paradigms, contribute practical solutions to theoretical problems, generalizations formulated in scientific terms, expansion of basic science or corroboration of the basic science. It is not possible to separate science and technology, since they are parts of the same process [8]

Referring to technology, it's easy to see as first limiting element to the following:

1. There is no clarity as to what is technology and technological innovation, which allows are established mental and social filters to stop the process of knowing on their specificity and generality, placing the matter in a kind of coming future.
2. Defining technology as the application of scientific knowledge seems not to fill the epistemological demands that a process of creating technology requires. Why do we say that not satisfy? Because, suffices studying any of the classical paradigms of the theory of science to see his inconsistency and his empiricist sense.

Not treated simply apply the scientific knowledge to create technology. To create something you must know not only what their scientific basics are, but you need to know *how to do it*. This is the difference and as allows to make technology (technological theory), that is new knowledge of a particular object or phenomenon. So it's not from pure thought which should be determined or defined technology, it is rather the social conditions that determine the degree of technological development, on which must be defined.

The technology as well as its fundamental features should be discussed in terms of new knowledge, that is acquired from the appropriation of a need felt by man in society. Since only through the contribution of different disciplines and criteria about the unfoldment of man and his needs, is that a sufficiently explanatory thinking is achieved, than they are those needs, the reason for them, and how to defeat and overcome them.

We are now in a position to examine the epistemological status of Engineering.

III. EPISTEMOLOGICAL STATUS OF ENGINEERING.

According to Hans Poser, engineering is a way of knowing distinct from science in its methods and goals. By their methods, because there is an engineering method is heuristic, and their goals, because engineering is not intended to achieve explanatory and predictive laws but problem solving bounded within a very short time [9].

Poser argues that the epistemological status of engineering would correspond to a technological science, distinguishing it from the technology because, in his view, it refers to real processes and artifacts.

To achieve its purpose, Poser establishes the traditional distinction between pure and applied science with creativity as a discriminating criterion. This enabled him to establish the difference between rules and laws, *know how and know why*.

On the other hand, our author discusses the criterion that seeks to identify the distinction between science and engineering based on the design of artifacts, since today, due to technological advances, it is not possible to treat the artifacts in the traditional manner. Poser wondering: is it a sheep cloned an artifact? Does heart transplantation or implantation of a pacemaker becomes me an artifact? In trying to answer these questions, we are confronted with the fact that the semantic content of many terms own of knowledge of engineers has changed to the point that a thorough review it is necessary. Therefore we must set up the difference between science and engineering from methodological and not ontological aspects.

Moreover, Can we move forward in the differentiation between science and engineering considering creativity as a distinct element? We think not. First, although the heuristic method involves creativity on the part of the engineer, this is not a major faculty. Second, it is possible to teach and learn engineering without being creative. So, What would be the differentiators elements between science and engineering? It is certainly the method used in both disciplines. Whereas it science seeks a universal truth, engineering is not set or truth or universality. The purpose of the engineer is utilitarian, while the purpose of the scientist is cognitive.

Regarding the method, engineering is characterized by the use of a heuristic method, focused on design or processes to enable the transformation of one situation A to another B to achieve a utility purpose. Instead, science use the explanatory method characterized by their nomological-deductive structure.

We can also consider that creativity is not a distinguishing factor among science and engineering since both domains of knowledge require it. A pure scientist seeks laws but also creates theories or hypotheses that can explain the reality studied. Scientific theories are creations of the human mind, and all scientific theory is always tentative. [10]

It is observed that both science and engineering are proposed to be rational; both claim to be naturalists domains, both are correctibles, therefore accept that their results are provisional.

The methodological difference that distinguishes it is: The scientific method begins with observation of a phenomenon only to be explained by a conjecture or hypothesis that is nothing more than a response to a 'question of scientific research'. On the other hand, the heuristic method is configured from an abnormality seen in everyday practice. This anomaly does not require research questions, but demand solutions. The solutions may or may not be expressed in mathematical language, however, are not hypotheses to undergo contrasting as it does science. On the contrary, the solution to an engineering problem or abnormality detected in the engineering field is the result of applying a practical rule that in turn, has been developed in the field of the same engineering. A favorable solution not represent a universal law, but is restricted to a rule of practical use of local and within a certain specialty and temporality. Therefore, engineering generates no laws or theories but in the best case, good practice guides bounded to the solution of specific problems.

Walter Vincent says that in order to solve engineering problems, engineers apply different knowledge that help design and are based on sources from different backgrounds, some from science and other developed internally by engineering itself, some clearly distinguishable and other not. Regardless of origin all of them share the fact are useful for solving practical problems [11]

Eugene Ferguson (1999) propose the thesis that much of the technological progress is due to a large number of decisions that are and should be taken by the technologist in unscientific way, rather a creative and intuitive way and therefore should be highly subjective and not bound by the rules of science. Ferguson states that the use he makes engineer of knowledge is purely instrumental, in the sense that only interested in its ability to predict behavior and not its potential to explain the laws of nature. That is why engineering is making use of theories and models that have been discarded by science for its loss of credibility, but are still useful for instrumental purposes for engineer activity [12].

IV. ENGINEER OR SCIENTIST: DEMARCATION CRITERION

It is impossible to define the engineer *by making*, since the activities covered in their various specialties are varied: telecommunications, public works, industry, agriculture, forestry, mining, aeronautics, to name some of the best known. It is, *how he does* what marks the identity of an engineer; that is, the method is what defines it. However, this method is hard to pin down, as to be the result of the combination of creative skills, knowledge and abilities, all of them easy to identify. In any case, it is something you learn with the exercise of the profession, but it requires you to properly lay the groundwork in Schools where engineers are formed.

The scientist is formed to achieve accuracy, precision and generality in a very limited domain knowledge, whereby it is isolated in his office or in his laboratory, and produces results in the form of propositions that are expressed by mathematical expressions or statements; while the other adopts a more pragmatic stance in the search for effective and satisfactory solutions to specific problems without being able to evade all its complexity, which usually takes the form of machines, appliances or systems. The first is, therefore, a knowledge that turns on itself; while the second come out the knowledge domain to nourish the concrete world of man-made objects. In this context it is also worth recalling the traditional role played by science in the training of engineers, which it has occupied a prominent place in contributing to the selection and training of the intellectual faculties of future engineers.

Both engineering and science, mathematical representations are used, that are by their very nature, most of the time, approximations. But these approaches have a different character for science and engineering. For the first are merely temporary in a persistent and unending search for truth, while for engineering is the approximation inherent in its own method, since the product operating correctly is what sanctions the work of engineer. The engineer must skillfully combine procedures available to achieve the desired solution, through a peculiar mixture of analytical methods and intuition, to reach an object than present this artificial behavior he pursues. The design of a car, a plane or a mobile phone does not follow any predetermined theoretical body, since there is no method or theory or set of them that "cover." There may be prior knowledge to calculate some of its parts, or suggest solutions to some of the subproblems in the design, but the design as a whole

is not apparent from any theoretical discipline. Analytical methods, which are so important in modern engineering, never provide a complete solution to the problem. They need to be complemented with creative processes on the one hand, and extensive experiments directly related to the system in question, on the other. This makes the engineering design is a complex process in which multiple skills are deployed by those who carry it out.

Sometimes it would even be the engineer himself who would develop a theory of the case that is working in a particular application, feeding what has come to be called engineering sciences. However, this is not the usual, and such claims handling would normally be used only by engineers working in research centers. The engineer, lacking complete knowledge about what is being designed, has to resort to heuristic rules [13].

As Simon, H. says: the scientist deals with things as they are, while the engineer does it in the manner how must be made to achieve a particular goal [14]. Something similar has expressed aeronautical engineer Theodore von Karman (1881-1963): the scientist describes what is; the engineer creates what never existed. These two quotes illustrate an easily recognizable differences between scientist and engineer. This does not exclude that there is a permeable boundary between them, and that the same person can be both: but always will be at different times. When acting as a scientist your goal is to know the properties of things, ultimately the natural world; while acting as an engineer what it will do is help to produce the artificial world in which we live. Consequently, in each case the rules to undergoing would be different. Therefore it is so different to be a good scientist and being a good engineer. Society clearly distinguishes them.

Furthermore, the engineer treats a specific problem, in a particularly case. He has been made to solve specific problems. If will reach generalizable solutions, the better, but that is not their goal. As scientific that looking for general results with universal validity is good but If your results are applied to concrete cases, it is better, but that is not what he wanted in the first place. [15]

In summary, the scientific engineer is one engineer who makes science on artificial objects, to help conceive, calculate and exploit labor and assume to tasks the methodical and systematic reflection on their own knowledge for the progress of artificial world

V. CONCLUSIONS

1. The application of science is only part of knowledge engineering. This does not mean that science does not represent any role, but this is not the only or necessarily the most important.
2. Both science and engineering are areas of rational knowledge; both are naturalistic, rectifiables and therefore accept their results as provisional
3. the use that engineer does of knowledge is purely instrumental, in the sense that only interested your ability to predict behaviors and not their potential to explain the laws of nature.
4. Science and Engineering are distinguished by the method and purpose seeking. The first applies the scientific method and its purpose is cognitive while the second applies the heuristic method and purpose is utilitarian.
5. Where a Engineer acts as a scientist seeks to know the properties of things to give more support to technology; when acting as an engineer what looking is to help to produce the artificial world in which we live. In each case, the rules submitted would be different,
6. The present study demonstrates that all curriculum in the formation of an engineer regarding your listing, must start from a clear and precise idea of what is knowledge in engineering and the role that science plays in this formation.

REFERENCES

[1] M. Bunge., “Technology as applied science" *Technology and culture,* 7:329-347. 1966, revised version reprinted in Mitcham and Mackey (below), pp. 62-76, and in Rapp (below), pp. 19-39.

[2] C. Mitcham and R. Mackey, “*Philosophy and technology”: readings in the philosphical problems of technology* . New York: free press, 1972.

[3] F. Rapp. C*ontributions to a philosophy of technology: Studies in the structure of thinking in the technological sciences* . dordrecht: reidel, 1974.

[4] De figueiredo, a. d. “Toward an epistemology of Engineering” retrieved from: http://ssrn.com/paper=1314224, 2008.

[5] S. Johnston, P. Gostelow and E. Jones, E. Engineering and society: An Australian Perspective*.* 2nd ed. 1999, Melbourne: longman

[6] E. Layton, Technology as knowledge. *technology and culture, 15*(1), 31-41, 1986.

[7] H. Padilla, Los objetos tecnológicos y su base gnoseológica. en: varios autores. La filosofía y la ciencia en nuestros días (México: editorial Grijalbo, 1976), pp. 157-170.

[8] D. Jiménez and Q. Gil, *Aportes para una epistemología de la tecnología (bases para una epistemología de la tecnología),* 2012.

[9] H. Poser; On structural differences between science and engineering. *phil & tech* 4:2, 1998.

[10] S. Hawking, ”Historia del tiempo”, edit. Planeta De Agostini, 1992, Barcelona, Spain, pp. 27-28.

[11] W. G. Vicenti *:* What Engineers Know and How They Know it, A*nalytical studies from aeronautical history*: Johns Hopkins university press, 1990.

[12] E. Ferguson, “Engineering and the mind’s eye”, MIT pres, Massachusetts, USA, 1999.

[13] B. Koen, . Discussion of the Method.,Oxford University Press, 2003.

[14] H. Simon, The Sciences of the Artificial., The MIT Press, 1996. versión Española *Las ciencias de lo artificial*, Comares 2006.

[15] P. Forman, Paul, The primacy of Science in modernity, of technology in postmodernity, and of ideology in the history of technology. *History and Technology* 23(1), 1–152, 2007.