On the Kinds of Problems Tackled by Science, Technology, and Professions: Building Foundations of Science Policy

Luis Marone[1]

Abstract — Science, technology, and professions form a system with strong interactions. Yet, these activities attack different kinds of problems which require different kinds of solutions. The problems that trigger scientific and technological research remain insufficiently solved or unsolved, therefore their possible solutions must be invented (i.e. they are partially or totally original) and, consequently, they should be tested against reality by researchers before considering them as true or useful. On the contrary, the problems that trigger professional inquiry are already solved, or have at least some partial solution at hand that is available in the form of a technical protocol. This solution is applied with caution but without testing (i.e. the professional assumes that the solution works because it was already challenged by researchers). Moreover, science and technology tackle unsolved inverse problems, which allow the radical advancement of knowledge, and genuine innovation. A science policy based on a clear distinction between creative and routine activities (i.e. a creatively friendly policy) offers an opportunity for societies to reach value-added innovative economic and integral development.

Résumé — La science, la technologie et les professions forment un système de fortes interactions. Pourtant, ces activités s'attaquent à différents types de problèmes qui nécessitent différentes solutions. Les problèmes qui aiguillonnent la recherche

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[1] **Luis Marone** earned his degree at the Universidad de La Plata, Argentina, in 1983, and his doctorate at the Universidad de San Luis, Argentina, in 1990, both in biological sciences. He has been a visiting professor at Argentinian universities (Buenos Aires, La Plata, Córdoba, Cuyo, Tucumán, Mar del Plata, Litoral, Río Cuarto, San Luis, Patagonia), as well as at the Universidad de Chile (Santiago, Chile), Playa Ancha (Viña del Mar, Chile), Castilla-La Mancha (Toledo, Spain), and Nacional (Heredia, Costa Rica). He carried out postdoctoral studies at the Philosophy of Science Unit, McGill University, Canada (1994, 1998), is a Guggenheim fellow (2003), and a Prince of Asturias (Young Natural Scientist) laureate (1983). He has authored or co-authored about 80 articles on ecology, environmental sciences, epistemology and methodology of science. Currently, Luis is a full professor of epistemology at the Universidad de Cuyo, and a CONICET researcher at ECODES, IADIZA, both in Mendoza, Argentina.

scientifique et technologique demeurent insuffisamment résolus ou non résolus, donc leurs possibles solutions doivent être inventées (c.-à-d. qu'elles sont partiellement ou totalement originales) et, par conséquent, elles doivent être testées contre la réalité par les chercheurs avant de les considérer comme vraies ou utiles. Par contre, les problèmes qui aiguillonnent une investigation professionnelle sont déjà résolus ou une solution partielle est disponible sous la forme d'un protocole technique. Cette solution est appliquée avec prudence sans être testée (c'est-à-dire que le professionnel suppose que la solution fonctionne parce qu'elle a déjà été mise à l'épreuve par les chercheurs). De plus, la science et la technologie s'attaquent à des problèmes inverses non résolus, ce qui permet l'avancement radical des connaissances par de véritables innovations. Une politique scientifique fondée sur une distinction claire entre les activités créatives et les activités routinières (c.-à-d. une politique respectueuse de la créativité) offre à la société la possibilité d'un développement économique et intégral à valeur ajoutée.

Those who design or put into practice scientific or technological policies must face the dilemma of discriminating scientific research correctly from its various related activities[2]. Although it seems a truism, failing to distinguish genuine scientific research from technology or from solving practical problems by the direct application of well-established solutions may be an obstacle to reach knowledge-based integral society development[3].

A first confusion is between basic science (i.e. the disinterested search for new scientific knowledge) and applied science (i.e. the search for new scientific knowledge of possible practical utilization)[4]. This mistake has some important implications. One of them is about scientists' rights to freely choose their research problems, which are more restricted in applied science[5]. Another implication is that whereas all outputs of basic research (i.e. both the provisional corroboration or refutation of ideas) are acceptable and useful in principle, the outputs of applied research that fail to corroborate a potentially applicable idea are "less useful" because they do not provide a technological *knob* to be further investigated and developed by technologists[6]. Consequently, the search for applied knowledge may impose some ethical dilemmas which are not

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[2] Bunge, « Ciencia básica, ciencia aplicada y técnica », 1997.

[3] *Ibid.*, Sábato, *Ensayos en campera*, 2004, Marone & González del Solar, « Imaginación e innovación », 2005, « El valor cultural de la ciencia y la tecnología », 2006, « Crítica, creatividad y rigor », 2007.

[4] Bunge, *Dictionary of Philosophy*, 1999.

[5] Bunge, *Doing Science*, 2017.

[6] Marone, « Aportes de la ciencia básica a la cultura y la sociedad », 1994.

always attended: the pressure to obtain and publish potentially applicable results (i.e. those that show that a given treatment has an effect) may predispose researchers against the null hypotheses of their statistical tests[7]. Such pressure goes against objectivity and demotivates the careful corroboration of robustness of research findings before publication[8].

Another confusion is between applied science and technology (i.e. the branch of knowledge concerned with designing new artefacts and action plans). Although modern technology is widely based on science (e.g. it is capable of being perfected with the help of scientific research), it should not be confused with applied science, since the latter is limited to seeking new knowledge with practical potential[9]. Implications of the mistake are the underestimation of the design phase and the economic constraints of genuine technological development. They are parts of the design of artefacts but not of applied science. Bunge evaluated some tunnel-viewed economicist "scientific" policies:

> When science is privatised, the scientific project turns at best into a technological adventure, without regard for either morality or the public interest. For example, some private pharmaceutical companies have patented many of our genes, so that we no longer fully own ourselves. *And some universities are currently trying to shift their professors from papers to patents.* Fortunately, others are working against this trend, and towards a free-access policy. For example, the exemplary Montreal Neurological Institute and Hospital is refusing to patent any of the discoveries of their researchers[10].

A scientific culture must emphasise intellectual enterprise and the finding of innovative ideas communicated by means of original papers, whereas a technological culture must promote practical thinking and the design of innovative artefacts. Despite these different goals, scientists often aspire to contribute basic information to technologists, and technologists read (and sometimes write) papers to find (or discuss with colleagues) some key pieces of

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[7] *Ibid.*

[8] Baker & Penny, « Is There a Reproducibility Crisis? », 2016.

[9] Bunge, *Dictionary of Philosophy*, 1999.

[10] Bunge, *Doing Science*, 2017, p. 42 (the italics are mine).

knowledge (e.g. possible technological *knobs*) that could inspire the devise of efficient artefacts. (By the way, such artefacts may occasionally be used by scientists for designing and performing experiments.) Emphasis on papers or patents should then be balanced in a healthy science-technology system[11].

Finally, an often-disregarded confusion is between science and technology, and the practical enterprise of using knowledge and artefacts (often developed by researchers and engineers) to solve local problems[12], in other words, using *professional* capacity to solve problems as craftsmen or servicemen[13]. This mistake may have harmful consequences for science and society. It is frequently committed by public servants and politicians who call for assembly-line products (e.g. vaccines, lithium chloride to produce lithium metal), or services (e.g. a DNA sequencing for a case of forensic medicine, or local sea pollution monitoring) from scientists and technologists, instead of asking for solutions to unsolved, authentic scientific or technological problems.

Herein, I will review the main characteristics of science, technology, and professions, with emphasis on the problems that these activities attempt to solve. In so doing, I will use and expand some concepts of Mario Bunge's philosophy. Important as the distinction between basic and applied science may be, I will nevertheless consider both disciplines together (i.e. "science") in this essay.

1] Problems in Science, Technology, and Professions

It is well known that engaging in an inquiry of any kind is to tackle cognitive problems. For example, a well-written scientific paper starts by stating the problems it tackles, and ends up by listing some open problems[14]. Epistemic or practical problems are knowledge gaps which can be handled in a promising fashion and which, to be authentic, must arise against some background knowledge rather than in a vacuum[15].

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[11] Sábato, *Ensayos en campera*, 2004.

[12] Marone & González del Solar, « Imaginación e innovación », 2005, « El valor cultural de la ciencia y la tecnología », 2006.

[13] Bunge, *Dictionary of Philosophy*, 1999.

[14] Bunge, *Chasing Reality*, 2006.

[15] Bunge, « Inverse Problems », 2019.

Marone and González del Solar[16] proposed that the kinds of problems confronting science, technology, and professions, and the nature of solutions that such problems require, reveal their similarities and differences (Table 1). Although science, technology, and professions form a system with context (e.g. the society in which they develop together with its cultural assumptions), composition (e.g. each activity), and structure (e.g. the flux of information between the components)[17], such activities start with problems of a very different kind. Science and technology apply scientific method to elucidate problems but, whereas scientific problems are purely cognitive, technological problems imply conceptual as well as practical challenges (Table 1). What problems in science and technology have in common is that they must both be questions that are not completely solved because a satisfactorily solved problem is neither scientific nor technological at present. This is the reason why genuine outputs of science and technology (i.e. "solutions to problems") must be original to some detectable degree and, consequently, they should offer the evidence that shows that the novel hypothesis is true to some degree or the novel artefact works, as part of their labour (Table 1). Thus, science and technology should provide society with the burden of proof. On the contrary, professions solve problems without the need of inventing original ideas, but using confirmed ones which professionals assume are correct (**Table 1**).

Unfortunately, some people confound the original products of science and technology with industrial products, be they mass-produced artefacts like telephones, or services like a proven therapy[18]. Assembly-line products and services use huge amounts of scientific and technological knowledge nowadays, but they do not carry out research. Of course, although professionals do not test the hypotheses that underpin their rules of action, they apply such rules cautiously, contemplating the contingencies that may affect their application, and monitoring partial results (e.g. think about a physician carefully applying a given therapy, or the so-called adaptive management in wildlife conservation). Lastly, professionals often

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[16] Marone & González del Solar, « Imaginación e innovación », 2005, « El valor cultural de la ciencia y la tecnología », 2006.

[17] Bunge, *Ontology II: A World of Systems*, 1979.

[18] Marone & González del Solar, « Imaginación e innovación », 2005, « El valor cultural de la ciencia y la tecnología », 2006.

detect new problems while monitoring their actions, some of which could be unsolved problems that will trigger scientific or technological investigation (e.g. when a physician detects a previously unreported syndrome, or when a technician identifies a consistent lack of efficiency in an artefact), highlighting the systemic nature of science, technology, and professions.

Given the central role that problems play in distinguishing science from its related activities, let's look in depth at the taxonomy of problems in order to offer a more complete characterisation of all three activities.

Table 1: Characteristics of problems, solutions, and proofs in three activities: Science, technology, and professions (services).

Properties	**Science**	**Technology**	**Professions**
Driving force	Curiosity	Curiosity—Practical	Practical
Goal	To know	To know and design	To apply a known solution to a "local problem"
Deals with problems	Cognitive—Unsolved	Cognitive and practical—Unsolved	Practical—Solved
Deals with problems *	**Inverse**—Direct	**Inverse**—Direct	**Direct**—Inverse
Solutions	Original	Original	"Already Proven"
Burden of proof	Its own	Its own	"Given"

* In bold letters, the most typical problem of every activity.

2] Direct and Inverse Problems

The philosophical literature about problems in general is poor[19]. Moreover, the most challenging and rewarding scientific and technological problems are inverse (or backward) problems, the existence of which is usually ignored by policy makers, public servants, and philosophers[20].

Bunge (2006) offered the following definitions:

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[19] Bunge, *Chasing Reality*, 2006, « Inverse Problems », 2019.

[20] *Ibid.*

> A direct or forward problem is one whose research goes down either the logical sequence or the stream of events; that is, from premise(s) to conclusion(s), or from cause(s) to effect(s).
>
> An inverse or backward problem is, in contrast, one whose research goes up either the logical sequence or the stream of events; that is, from conclusion to premise(s), or from effect to cause(s).

Direct problems call for analysis, or progressive reasoning, but inverse problems require synthesis, or regressive reasoning. Work on direct problems is basically one of discovery (i.e. unveiling the consequences of a known process), whereas the investigation of inverse problems usually calls for creativity and radical invention of ideas in science, and devices in technology[21].

Some not completely independent examples of inverse problems are (a) guessing an unobservable object from the behaviour of observable things, (b) conjecturing the mechanism involved in changes of observable things, and (c) guessing the cause of something given certain effects. All the attempts of going up from data to hypothesis as the "problem of induction"[22], "abduction"[23], "inference to the best explanation"[24], or to "free creations of the human mind"[25] are inverse problems[26]. Guessing natural selection from phenotypic variability and resource shortening, constructing empirical or physiological models for studying seedling emergence, inferring the distribution of a bird population or metapopulation from a set of isolated geographical "records", or guessing an *unknown* illness from its symptoms are all examples of inverse scientific problems. The radical inventions of new devices or the finding of a new use for an extant device are, in turn, examples of inverse technical problems.

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[21] Bunge, *Chasing Reality*, 2006.

[22] *Ibid.*

[23] Peirce, *Collected Papers of Charles Sanders Peirce : Pragmatism and Pragmaticism*, 1934.

[24] Harman, « The Inference to the Best Explanation », 1965.

[25] Einstein, *Out of My Later Years*, 1950.

[26] Bunge, *Chasing Reality*, 2006.

In contrast, predicting phenotypic changes starting with natural selection[27], seedling emergence from physiological models[28], the presence of individuals at a given location starting with the theoretical population distribution[29], the manifestation of certain symptoms given a known illness, or the output of an artefact (e.g. be it a robot or a therapy) knowing the way the artefact works (e.g. the theory on which it is based), are all direct problems. (Note that all these direct problems enable us to test the hypotheses guessed or inferred while resolving the corresponding inverse problems; see the previous paragraph).

Inverse problems may have multiple solutions or none[30]. The invention of theoretical hypotheses is a good example because, by definition, a hypothesis goes beyond the data relevant to it in at least one of two ways: either because the hypothesis involves a leap from some existents (sample) to all possibles (universe), or because it includes concepts that, like those of mass, behaviour, competition, natural selection, or national sovereignty, do not occur in the data because they are not experiential in a direct way[31]. There can be no "vertical" inference from data to high level laws because the latter contain concepts absent from the former. Since experience cannot generate any high-level concepts or hypotheses, these must be invented. And invention is anything but a rule-directed process, one subject to algorithms that could be fed into a computer. In short, since data do not exude hypotheses, hypotheses must be invented (an inverse problem) and, of course, more than one hypothesis can be invented to account for the same pattern or problem[32].

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[27] Marone *et al.*, « La teoría de evolución por selección natural como premisa de la investigación ecológica », 2002.

[28] Rotundo, Aguiar & Benech-Arnold, « Understanding erratic seedling emergence in perennial grasses using physiological models and field experimentation », 2015.

[29] Cueto *et al.*, « Distribución geográfica y patrones de movimiento de la Monterita Canela (*Poospiza ornata*) y el Yal Carbonero (*Phrygilus carbonarius*) en Argentina. », 2011.

[30] Bunge, *Chasing Reality*, 2006.

[31] *Ibid.*

[32] *Ibid.*

3] Science and Technology Attack Inverse Problems to Reach Radical Invention

Most demanding and interesting scientific and technological problems are inverse: given an unsolved problem, scientists and technologists must infer or guess the solution. The Problem → Solution(s) scheme depicts an inverse problem. However, science and technology also need to solve important direct problems, particularly when they put to trial hypotheses invented to solve the inverse problems. In such cases, scientists "transform"[33] an inverse problem into a direct one:

> Evolutionary biology, like cosmology, geology, and archaeology, is a historical science. Hence its practitioners face a large family of inverse problems of the Present → Past type. In particular, the reconstruction of any lineage (or phylogeny) is tentative if only because of the large gaps in the fossil record. However, qualitative novelties emerge in the course of individual development, which can be monitored and altered in the laboratory. Therefore, some of those novelties can be caused deliberately in modern organisms. This is why some inverse problems in evolutionary biology and genetics can be transformed into direct problems, at least in principle. Actually, this is how evolutionary biology became an experimental science between the two world wars: by tampering with the genome, first with X-rays, and nowadays chemically as well. […] Certainly, evolutionary biology is not the sole abode of inverse biological problems. Every attempt to find the unknown organ that discharges a known function (or performs a certain role) requires research into an inverse problem. This holds, in particular, for the task of the cognitive neuroscientist, said to be that of "mapping the mind onto the brain". However, here too many an inverse problem can be transformed into a direct one. For example, by tampering with the brain, the neuropsychologist can cause mental disorders or deficits in experimental subjects. […] The problem of identifying the gene(s) "responsible" for a given phenotypic trait is of the inverse type. For example, if an adult mammal does not tolerate dairy products, it is because it cannot synthesize lactase, the enzyme involved in the digestion of milk; and in turn lactase deficiency is due to the lack of the gene involved in its synthesis. The researcher is thus faced with

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[33] Sensu *ibid.*

> the inverse problem: Metabolic disorder → Enzyme deficiency → Genetic disorder. Once the suspect genes have been fingered, the problems of finding out the corresponding enzymes can be tackled. The solution to these direct problems should solve the original inverse problem[34].

This is the interplay of inverse and direct problems in science. In technology, it follows a similar path. Convincingly, however, in science and technology inverse problems are more intriguing, more demanding in ingenuity and experience than the corresponding direct problems. Unlike direct problems, there are no special rules or algorithms for solving the most fascinating inverse problems. But once a tentative solution is at hand, researchers "transform"[35] the inverse problem into one or more direct ones to test the degree of truth or the efficacy of the proposed solution. An issue that public servants in science and technology, the media, and people in general do not always consider is that inverse problem solving is a risky and uncertain task. To solve them, scientists propose plausible but original hypotheses that could be right but also (most times) could be wrong. Society and officials should be prepared to stimulate (responsible) adventure, without punishment to (responsible) researchers who fail to find a solution to a difficult inverse problem.

What about professional problems? Professional activity often begins by diagnosing the origin or cause of a problematic situation (e.g. illness from symptoms, artefacts break from malfunction, nitrogen deficiency from crop decay, food resources decline from consumer population reduction). It uses the scheme Effects → Cause(s), which is an inverse problem. The inverse problems tackled by professionals have nevertheless some peculiarities. Firstly, they only characterise the initial phase of professions (i.e. diagnosis), but not the typical and important phase of problem solving (i.e. action). Secondly, professional diagnosis is carried out by using previously built critical pathways, which go through the stream of events along a known pathway that has already been investigated and established by researchers as a protocol, or even an algorithm.

After diagnosis is made, the typical professional problem is a direct one. Professionals assume the diagnosed cause and, then

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[34] *Ibid.*, p. 169-170.

[35] Sensu Bunge, *Chasing Reality*, 2006.

arbitrate the means (rules) to control outputs or effects through a direct problem of the form Cause → Effect(s). Rules may be applied, for instance, to fabricate vaccines or tablets, to administrate a therapy or an action plan for the management of a complex organisation. Updated knowledge, critical thinking, and responsibility—but not originality—are the hallmarks of professions. A sick person of a tractable illness demands a wise and accountable physician, but not a creative (let alone reckless) one. Professionals often solve direct problems in a routine fashion since they calculate building structures, carry out biochemical analyses, produce high-quality chocolate, monitor the organic material in a stream or people's body temperature, or determine the traceability of imported products.

Finally, almost the whole national budget of developed and developing countries (often>99%) is devoted to "professional policy" (e.g. public health, education, justice, infrastructure, logistic, product or service provision), whereas just a small fraction is devoted to science and technology (the figures are here notably variable between countries but usually <1%). Bunge warned that some universities are trying to shift their professors from papers to patents[36]. His warning should be extended: some politicians and public servants are trying to shift researchers from papers and patents to the development of mass-produced artefacts or services. In doing so, the 1% national budget would subsidise the other 99%. Politicians do not appear to appreciate that, to a large extent, science and technology are directed to resolve unsolved inverse problems. When routine activities replace original and risky ones, some cultural values like creativity and imagination are discouraged. This hampers value-added innovative economic and integral development of societies[37].

In the next section I will assess, as an example, the interplay of direct and inverse problems in a specific area of knowledge: translational medicine.

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[36] Bunge, *Doing Science*, 2017, « Evaluating Scientific Research Projects », 2017.

[37] Bunge, « Ciencia básica, ciencia aplicada y técnica », 1997, Sábato, *Ensayos en campera*, 2004, Marone & González del Solar, « Imaginación e innovación », 2005, « El valor cultural de la ciencia y la tecnología », 2006, « Crítica, creatividad y rigor », 2007.

4] Case Study: Translational Medicine

Translational medicine was created with the commendable goal of facilitating the transformation of basic research results into clinical applications. It aims at establishing bridges between the so-called basic and clinical medicine, bridges than can help in "crossing the valley of death"[38], an area of knowledge that despite years of basic research would not have resulted in sufficient profits in terms of new treatments, diagnoses and prevention protocols[39].

Translational medicine consists of two stages or approaches. The goal of T1 is to guide basic knowledge for the development of drugs, diagnostic markers or treatments. In other words, to invent promising treatments that can be mass-produced by the pharmaceutical industry and used in clinical medicine. The objective of T2, in contrast, is assuring that the new treatments developed in T1 are applied correctly to sick populations. The production of a new drug could, therefore, be the final point of T1 and the starting point of T2, since T2 looks to improving the organization of the health system, making it accessible to the whole population[40].

Butler asserted that basic and clinical research had strong relationships during the first half of the twentieth century, but the situation radically changed with the commencement of molecular biology in the 1970s[41]. Translational medicine was then an attempt to put both disciplines together again. However, the best application of translational medicine confronts various dilemmas, one of which is avoiding the confusion between "the invention of treatments" and "carrying them out in practice"[42]. Another dilemma is that T1 appears to hoard most of the grants in the biomedical sciences[43].

The application of the model in Table 1 to distinguish basic and clinical research makes clear that clinics incorporate some professional characteristics (e.g. the proximity to patients).

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[38] Butler, « Translational Research », 2008.

[39] Becú-Villalobos, « Medicina traslacional », 2014.

[40] Butler, « Translational Research », 2008, Becú-Villalobos, « Medicina traslacional », 2014.

[41] Butler, « Translational Research », 2008.

[42] Becú-Villalobos, « Medicina traslacional », 2014.

[43] *Ibid.*

Notwithstanding, both activities refer primarily to research, although differing in the way they carry out the task. Both confront similar inverse problems (e.g. inferring original hypotheses about an unknown illness) but, while clinical research is directed towards finding disease-pattern hypothesis in actual human populations by using observational-correlational approaches (i.e. it is some kind of instrumentalist research), the so-called basic research (which, by the way, should be better named "lab research") is more usually directed towards finding and testing hypotheses on causal mechanisms of illness by using distinct laboratory settings and experimentation (i.e. it is realistic research)[44]. Although such epistemic differences are usually clear, researchers and meta-scientists scarcely explore them. The professional and investigative sides of the basic/clinical approaches have not received sufficient attention.

Translational medicine includes the scientific and technological, as well as professional, phases of the discipline in a clearer, although usually implicit, way. From definitions and according to Table 1, T1 develops science and technology, but not professions (e.g. T1 develops biomarkers, gene therapy or pharmaco-genomics). T1 would conclude when the prototype of a new device has been developed and tested. T2, in turn, is primarily professional because its main target is the organization of health services to reach the whole society. T2, notwithstanding, can also investigate because it might occasionally face some unsolved problems. But T2 research is not proper biomedical research because it confronts problems typical of the behavioural and social sciences (e.g. which actions better stimulate vaccination adherence, the dialogue between researchers and physicians, or the commitment of patients to therapy; which accounting tools assure the availability of hospital inputs despite erratic funding; what plans optimise the flux of information within the hospital). The kind of problem investigated, the environment (e.g. a hospital) in which the inquiry is carried out, and the devices used for obtaining information are substantially different between T1 and T2. Incidentally, such differences can partially explain and justify distinct grant sizes in T1 and T2.

An important final point, when T2 claims public funding to enhance the provision of hospital nursing, to improve the patient/physician ratio, to buy drugs, or finance the training of hospital staff,

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[44] Bunge, *Medical Philosophy*, 2013.

such public funds should not come from scientific and technological granting agencies but from professional agencies (e.g. the Ministry of Health) directed to assure the provision of appropriate health services. Said in another way, the usually scarce funds intended to promote innovation will not be used to solve professional problems.

5] Conclusions

Science, technology, and professions form a system with multiple interactions, all of which are important human activities, and none of them may be considered hierarchically superior to the others. The development of each activity drives the progress of the others, generating virtuous circles of problem solving, tackling different kinds of problems. In some instances, the same person can advance two or even the three activities simultaneously. Nevertheless, similarities and even synergism should not lead to a confusion between science, technology, and professions. Confusing the creative with the routine activities may be particularly pernicious for the advancement of them all.

The problems that trigger scientific and technological research remain insufficiently solved or unsolved, therefore their possible solutions must be invented (i.e. they are partially or totally original) and, consequently, they should be tested against reality by researchers before considering them as true or useful. On the contrary, the problems that trigger professional inquiry are already solved, or have at least some partial solution at hand that is available in the form of a technical protocol. This solution is applied with caution but without testing (i.e. the professional assumes that the solution works because it was already challenged by researchers). Whereas all activities benefit from an informed and critical education, science and technology also need an education prone to creativity, imagination, and risk in order to flourish.

Mario Bunge's assessment of inverse and direct problems may be a fertile way to assess science, technology, and professions[45]. A direct problem is one whose research goes down the stream of events, whereas an inverse problem is one whose research goes up the stream of events. The most exciting problems are inverse scientific and technological ones (i.e. the invention of a plausible solution to

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[45] Bunge, *Chasing Reality*, 2006.

an unsolved question), although both activities also resolve direct problems (e.g. the deduction of predictions for testing hypotheses or prototypes). In contrast, the typical professional problems are direct ones (e.g. action or the application of a given protocol to resolve a local problem). Professionals, however, resolve inverse problems during the diagnostic phase of their activity as well (e.g. when an electrical technician goes from a light cut to a short circuit), but the diagnostic pathway in the professional activity has been previously established and described in a protocol (the problem, however, may have multiple solutions, which is typical of inverse problems). The model based on unsolved/inverse *against* solved/direct problems may be especially suitable to evaluate the scientific, technological, and professional phases of several complex human activities like translational medicine.

It is the task of the philosopher and sociologist of science to emphasise the role of original thinking in science, technology, and integral social development[46] (Einstein 1950, Bunge 1997, Sábato 2004, Marone and González del Solar 2007), especially in developing countries. People in these countries rarely benefit from an innovation-based economy and development themselves because their officials in the educational system only associate creativity, originality, and imagination with the fine arts.

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[46] Einstein, *Out of My Later Years*, 1950, Bunge, « Ciencia básica, ciencia aplicada y técnica », 1997, Sábato, *Ensayos en campera*, 2004, Marone & González del Solar, « Crítica, creatividad y rigor », 2007.

friendship. This is contribution number 106 of the Desert Com-munity Ecology Research Team (Ecodes).

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