

Title: Medicine, epistemology and constructional paradoxes

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Abstract

The present study examines medical knowledge and practice (educational goals in medicine) from a philosophical point of view, i.e. interprets it in the light of dialectical materialism, which describes precisely the way doctors and other health professionals worldwide, perceive their work and how they gain –even without realizing it– the necessary knowledge for it. Thus, it essentially constitutes a *materialistic critique* of other philosophical views, most particularly constructivism, whose supporters, already since the middle of the previous century to present day, contend these views to be the epistemological background of medical (and other disciplines) science, claiming the creation of educational-instructional programs based on them, overwhelming the current scientific medical literature. These philosophical views, in fact, question the existence of an objective reality and our ability to perceive and intervene in it, in order to serve people's needs. In the text, the anti-scientific basis of these philosophical-epistemological viewpoints, as opposed to dialectical materialism, becomes apparent. Furthermore, a *parallelism is made between various epistemologies with set-theoretic issues* (especially with the bases of set-theory and the Russell's paradox), giving clear indications of an 'inherent structural instability' of the non-materialistic philosophical systems, and, therefore, uncovering their inadequacy in forming a stable and consistent epistemological basis for medical science. To note, the 'parallelism' of set-theoretic considerations with the corresponding philosophical views, regarding the construction of each 'epistemological universe', is not some kind of 'mathematical proof' but rather a **'translation' of these philosophical views into another language**. Mathematics can be seen as the most basic/abstract way in which we can describe the structure and kinesis of phenomena in any – perhaps– cognitive field. Thus, mathematical approaches, with the resulting contradictions and/or verifications, may be used to present, by generalizing, the way various philosophical epistemologies aim to 'explain' the acquisition process along with the content of our knowledge regarding the objective reality. The point is, of course, that even if, following certain contemporary philosophical views, one can accept that 'everything goes', the same does not apply in mathematics –at least not yet. In science, what is mathematically invalidated cannot be accepted; in other words, a theory that ends up in an 'absurd' conclusion is not valid. Finally, new concepts are introduced, as the *inflation of information* (based on Marx's definition of inflation in the economy), which is related to the flow and reliability of information, including medicine, in our digital era; and its association with the 'constructs' of the above mentioned philosophical views is presented.

Where is the wisdom we have lost in knowledge?
Where is the knowledge we have lost in information?

Thomas S. Eliot (1888-1965),

The Rock (1934)

PART I

Theory and practice in the build-up of knowledge in medicine

A. Initially, the object of the medical doctor's (or other healthcare professional's) work is the best possible care of patients who present with specific medical conditions, which should be addressed by utilizing both sophisticated medical equipment and intellectual means. Necessary conditions for safety and effectiveness are excellent theoretical medical knowledge, high-level clinical skills, decision making ability, and finally dedication and adaptability in every day practice¹. At the base of this simple and generally accepted proposition, however, some particularly important assumptions exist. First of all, the doctor **acts** with the aim of bringing about a **change** in the world. Though, not just any change, but the specific one expected to be beneficial for the patient and the society in which he lives and works, e.g. to cure the patient, leading to what this entails, not only for him but also for his family and society in general. In order to achieve this change he has, consciously and deliberately, planned in detail and carried out his actions (physical examination, laboratory testing, medical treatments, surgical interventions, etc.). At deeper thought, every conscious and deliberate action is done to bring about some change. Marx, in his thesis **XI** on Feuerbach², reveals, in fact, what every human action aims for, that is, the change that it brings about in the world, saying: "Philosophers have hitherto only interpreted the world in various ways; the point is to change it." Obviously, we cannot change the material world 'quantitatively', i.e. we do not have the ability to add or remove 'matter'; all we can do –which is by no means negligible– is to actively interfere with its 'motion'. Now, how, really, is the necessary knowledge for action acquired? Knowledge in the field of medical science (like any knowledge about nature) is **acquired in practice**, by working out ideas in the effort to solve practical problems (e.g. the emergence of a medical problem is the trigger for taking action to solve it). On the other hand, the elaboration of theoretical solutions depends on the existing social experience, the already accumulated knowledge and, based on these, the logical processing of the available new data (cognitive elements) and reasoning. In conclusion, it has to do with the specific stage of social development and the development of science. The acquired knowledge is a **social product**. It is, of course, produced by individuals (e.g. doctors, medical researchers), which have become conditioned in a specific social environment, collaborating with other members of it, sharing ideas and experiences; finally also using the available means/tools as well as the knowledge which is already stored in the society. In this way, knowledge is expanded and deepened, both, by addressing the needs that continuously arise and relying, always, on the opportunities and the new capabilities created by practice. Finally, the knowledge that results from practice is **tested in practice**. Marx, in his thesis **II** on Feuerbach², specifically, mentions: "The question whether objective truth can be attributed to human thinking is not a question of theory but is a practical question. Man must prove the truth, i.e., the reality and power, the sidedness [Diesseitigkeit] of his thinking, in practice. The dispute over the reality or non-reality of thinking which is isolated from practice is a purely scholastic question." Thus, the knowledge for the resolution of a specific medical problem can

only be achieved when the 'claim' for resolving this becomes a practical question. The doctor does not meditate, for example, on the disease or its treatment in general, but examines the patient and requests diagnostic tests before deciding on the final diagnosis and treatment; similarly medical researchers perform clinical trials before the final approval for wide use of any drug, etc.

B. In the process of acquiring knowledge, where does the doctor rely on, how the gathered information –which ultimately is integrated into knowledge– is being received? The answer is that he obtains all information **through his senses** as he interacts with the things/people he relates to, which become the objects of his practical engagement, investigation and knowledge. Through the senses, he observes and perceives, for example, the patient's health problems and proceeds to judgments and propositions that are followed either by decisions for the appropriate treatment or by further efforts for making new observations, i.e. obtaining new information, through further interaction with the patient, in order to reveal elements concerning his health problem that were not immediately noticeable (e.g. the patient is submitted to clinical or laboratory tests), which will lead to new judgments, and so on. It should be noted that his **observations are not mainly passive but active**, i.e. they arise through his actions, his association with the objects that exist in his circle of interest. It is clear that in the process of acquiring knowledge, the doctor passes from **superficial knowledge**, to increasingly **deeper knowledge**, which depends on the level of scientific development in his specific, in time and space, working environment. Medical science, nowadays, has explicated significantly the association between the appearance of diseases (immediately evident to observation as symptoms and signs) with the hidden biological-pathophysiological processes underlying the observed appearances. That being so, disease categories have been established and treatments have developed, no longer for the 'correction' of the pathological appearance (symptomatic treatment) but for the treatment of the underlying pathological cause (etiological treatment). This profound development of medical knowledge and the knowledge of human physiology is necessarily associated with a **corresponding advance in practice**. One is not possible without the other; for example, without the knowledge in genetics and the technical means necessary for the development of molecular diagnostic techniques it would not be possible for doctors to rapidly detect infectious agents in sepsis and apply appropriate treatment. At each specific point of scientific development, of course, medical knowledge is confronted with certain **limitations** defined by the finite available experience but also by the specific available means to investigate nature, i.e. it is incomplete and provisional. Limitations, however, which sooner or later, human effort overcomes, in order to set new ones again, and so on. In agreement with Engels³, it is difficult to perceive an end in the knowledge acquisition process, as one could ever have reached the so called absolute truth –the particular one in medicine and human physiology not being excluded. Furthermore, the doctor faces an **objective reality**, i.e. existing outside and independently of his consciousness–reality is not a product of his thought. He discusses it with his colleagues, who see the same real world, i.e. the same patient with the specific symptoms and signs, laboratory test results, etc. Doctors do not negotiate about different perceptions of reality (error, negligence or lack of knowledge on the part of any of the healthcare professionals is another issue) but discuss e.g. about the diagnosis based on the objective data they collect. Thus, for the doctor, as for every scholar in science, his knowledge is **objective and absolute**, because it concerns the objective reality of the material world; though, at the same time it can be considered '**relative**' since this knowledge is in constant 'motion', as matter is, the 'modes of motion' of which a scientist never ceases to discover: "Πάντα ῥεῖ" (Panta rei) i.e.

"everything flows" (Heraclitus). Finally, the special attention given, along with the correct diagnosis, to the administered treatment (which almost always result from randomized, controlled studies and, often, take the form of guidelines so that, in general, the desired outcome is ensured with the greatest probability), highlights the admission of **causality** (every effect has an antecedent, proximate cause) in the phenomena, in the field of medical science: doctors, expect a specific progress of the disease, can make predictions, recognize risk factors and, additionally, anticipate a therapeutic effect from applied treatments. In summary, the **acceptance of objective reality** (i.e. being outside the individual consciousness), the **acceptance of causality** (indicating the existence of laws underlying the processes in nature – again, the possible 'side effects' is another issue) and the **connection of knowledge with practice**, are epistemological principles, accepted, consciously or unconsciously as such, by each physician in his daily practice.

C. If we now think abstractly about the above-mentioned process of acquiring knowledge, in the field of medicine, along with its practical application, we will recognize that it has its **source** in the emergence of '**contradictions**' (perceived as dipoles of interconnected parts), or else, in the '**struggle** between opposites' (e.g. disease-health, patient-doctor, need for additional knowledge-ignorance, etc.) that involve the doctor's relationship with his patient. Notably, the "doctor" title is realized and verified through the above relationship. The doctor gradually acquires knowledge about the patient's health problem by collecting informational data, reaching, **quantitatively**, to a decisive point, regarding deeper understanding of the patient's medical issue, which will lead to a **qualitative** change in the doctor's knowledge, i.e. to the correct diagnosis, resulting in a more effective medical management. The same applies to the elucidation of the etiology of certain illnesses, where knowledge accumulates gradually and, at some point, becomes critical, leading to qualitative –revolutionary– changes concerning the understanding of the pathophysiological background of the disease and its therapy; e.g. from the symptomatic treatment of a febrile illness to the etiological treatment of the pneumococcal pneumonia responsible for it. Finally, with the **resolution of the contradictions**, –being intrinsic elements in the relationship between the doctor and his patient– which occurs e.g. with the treatment of the patient, we can consider that, temporarily, the 'title' of the doctor is **negated**, ceases to exist (for the specific patient), to **re-emerge** in his relationship with another patient (or the same patient if he becomes sick again). Though now at a higher level, with more experience on the doctor's part in handling this 'relationship', which will probably lead to **more effective action**, since, in this chain of interconnected transitions, the doctor does not forget his previous experiences but takes from each one all that is positive and viable. This process shows exactly the **direction, form and result** of the development of knowledge. The one most versed in **dialectics** will surely have recognized in the above the **laws of the motion of matter** (which also concern the knowledge process) according to dialectical materialism (Engels)⁴: **a.** the law of the unity and struggle of opposites, **b.** the law of the passage of quantitative changes into qualitative changes and vice-versa and **c.** the law of the negation of the negation.

Interestingly, Prof. Thomas Kuhn pictures the history of science as periodic revolutions in knowledge (being also considered qualitative changes), punctuating long periods of merely quantitative change⁵.

Bypassing a 'disparaging smile' that the discussion above could cause as an extra-verbal comment of the type 'why are we now discussing the obvious', one could give the following reasons: **a.** to make clear that as trivial and obvious as the above may seem, it is of enormous

importance for the revelation and understanding of the **philosophical-epistemological basis of medical knowledge and practice**; i.e. the 'obvious' is exactly how **dialectical materialism** describes the process of acquiring knowledge⁶, and **b.** to point out that, nowadays –with the universally acknowledged, enormous progress of science and technology, including that in the field of medicine–, in contrast to dialectical materialism, but also to the reality as experienced by healthcare workers around the world, a multitude of philosophical views on knowledge and reality, postulate that **a'**. there is no knowable objective world and **b'**. there is no causality or laws governing the evolution of natural phenomena/processes. Both these views end up questioning the possibility or effectiveness of any human intervention in nature in order to serve human needs. Most surprisingly, proponents of such theories contend that these might provide the background for the design of instructional strategies in the context of healthcare education (see Paradigm in the PART II section). These postulates are briefly discussed in the Appendix; nevertheless, an everyday, tangible paradigm that overturns these perspectives is certainly the doctor who saves a human life!

Knowledge in the digital era and the inflation of information

The contemporary scholar, almost in every scientific discipline, faces the challenges arising from the enormous **growth of current knowledge/information** on the one hand, which might facilitate the scientific research^{7,8}, and the shrinking half-life of knowledge on the other⁹. For the interpretation of the phenomenon two questions should be asked. Is there really an increase in the demand for knowledge or in the depth and breadth of knowledge to the extent that justifies this increased information flow? Is the reduction of the half-life of circulating knowledge equivalent to practical changes in any scientific field occurring in parallel? Certainly, an important factor that has been implicated for expanding public availability of knowledge/information (or what appears as such) has to do with the way (the 'how') this occurs. It is the great development of informatics and the easy access to technology tools (internet as a knowledge resource) for the people. Due to the particular characteristics of this specific access to knowledge/information, a new learning theory has been introduced: **connectivism**^{10,11} ("integrating principles explored by chaos, network, and complexity and self-organization theories"¹⁰). Since exponential growth in knowledge as well as increased information flow via the internet is also being observed in the field of medicine¹², it would be appropriate to make some remarks: **a.** This particular learning theory describes mainly the changes in the way of accessing and propagating information among users, but not the quality of the circulated information, its relationship with objective reality and, ultimately, its validity and reliability. A number of publications¹³⁻¹⁵ refer to **misinformation exposure in social media**, also in the public health sector (the recently circulated information about COVID-19¹⁵ is a shocking example), even suggesting ways to identify credible sources (!). **b.** A different learning process in our digital era has been described, i.e. **a'**. "knowledge is no longer acquired in the linear manner"¹⁰, **b'**. according to Winn (cited by Ertmer and Newby)¹⁶ "Children raised with the computer think differently from the rest of us. They develop hypertext minds. They leap around. It's as though their cognitive structures were parallel not sequential". What is the result of the described non-linear but parallel intake/processing of cognitive data? Perhaps, by borrowing concepts from trivial physics, we can answer the question: for a continuous information flow (current), the '**parallel cognitive connection**' **reduces the overall 'resistance'** (meaning the effort/'struggle' to process and evaluate the information before its final acceptance) of the cognitive system of the receiver **while at the same time exhausting**

its capacity ('it takes up a lot of space' i.e. increases cognitive load). Alternatively, much greater 'resistance' is needed on the part of the receiver to avoid the overwhelming influx and final recording/acceptance of informational data (being also of questionable validity) in his cognitive system and the 'burn-out'. c. A final remark on the overwhelming amount of information that is traded as 'knowledge': epistemological theses exist that, in a way, 'justify' or are even implicated in the huge volume of circulating information, e.g. constructivism¹⁷ and post-empiricism¹⁸. For constructivism in particular, no comparison can be made, regarding the validity, among different, competing theories and concepts, since each individual determines his own version of reality, creates/'constructs' his own facts. There are no absolute standards against which any theory could oppose a different, competing view. If some standards were to be created, on the context of a metatheory, these would be constructs also, perceived differently by each individual¹⁹; there is only area for, at best, accommodating negotiation. As von Glasersfeld notes²⁰: "I would be contradicting one of the basic principles of my own theory if I were to claim that the constructivist approach proved a true description of an objective state of affairs...", that is, radical (i.e. totally consistent) constructivism is no more true than other theories. In this way, a plurality of theories and concepts can be produced, equally supported and retained¹⁹.

Based on the above –and considering knowledge as a broad, deep, and contextually specific set of information, which allows conscious and deliberate action in dealing with objective, material circumstances, being the trigger for its acquisition– we could parallel this increased information flow with the state of **inflation** in the economy (as described by Marx²¹), i.e. depreciation of the currency: "high prices caused by an over-issue of inconvertible paper money". Similarly we would talk about **inflation of information**, i.e. over-issue of inconvertible information (information that cannot be converted into knowledge of objective reality, but instead makes it difficult or prevents its acquisition). Such can be the non-relevant, of very little importance or false information but even the so called 'information/knowledge' that claim the non-existence of objective reality or the impossibility of knowing it! In fact, it seems that in today's era, the excess issue of such inconvertible information is reaching the critical point where information/knowledge is "falling into general disrepute". The 'everything goes' and the irrational look at reality in the post-empiricism era is a serious indication of this^{22,23}.

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PART II

Simulation Based Learning and Constructivism: a paradigm

Simulation Based Learning (SBL) is increasingly used in education in healthcare¹, both during undergraduate studies and in postgraduate education, but also for the continuous training and development of healthcare professionals, offering a relevant learning experience that is also safe, i.e. it does not put patients at risk. Learning theories, which describe how learners acquire, process, record, retain and recall new knowledge, and which may form the conceptual framework of an SBL event design are^{2,3} **behaviorism, cognitivism and constructivism**. Behaviorism and cognitivism mainly describe the way of knowledge acquisition, without questioning its relation with objective reality. Constructivism⁴ is not actually a learning theory but an epistemology –although some of its tenets have been engaged in students learning, mainly in instructional design, to ensure the active involvement of the students in the learning process. This is not to be underestimated, quite the opposite. Practice is crucial in the learning-cognitive process (**experiential learning**⁵); thus, it is very important for students or residents, for example, to 'learn' (acquire knowledge) while practicing under real conditions or –in the case that SBL is used –conditions that simulate reality. To note, studies emphasize the importance of **fidelity** (structural and functional or physical resemblance and functional task alignment respectively)⁶ in SBL sessions, depending, nevertheless, on the educational goals and the learners' cognitive level, for the best learning result.

However, despite the many different offshoots of the constructivist school, its basic epistemological doctrine assumes that the learner constructs **his own meaning of reality** and arrives at **his own version of the truth** through his new experiences during the learning event, based on his previous experiences and already established knowledge (background), i.e. knowledge is not delivered by the educator but is constructed in the mind of the learner⁷. Social constructivism⁸ may focus its attention on the influence of society and culture (that is, the individuals, i.e. educators or peers, who interact with the learner and support his cognitive development), but this does not change the basic 'condition' of constructivism; the others, with whom the learner socially interacts, simply act as 'carriers', in a way, of the experience that the learner will have, which finally will be processed and shaped into subjective knowledge by him alone. No objectivity holds. Thus, the educator during the learning event, acts as a **facilitator**, who remains neutral ideally, assisting the others/group to function effectively during their pursuit of objectives, decision-making or reaching a consensus on any disagreement that pre-existed or may emerge. Though, that's not how things work at SBL in the field of healthcare. Reviews on constructivism as the epistemological background of SBL in healthcare^{2,3}, point out that learners may possibly build inaccurate or invalid knowledge, as all learners will not necessarily experience the same learning based on the event. Thus, they emphasize the importance of **debriefing**⁹ so that the facilitators/educators monitor and guide student thinking, in order to reach not their own 'constructs' but the necessary, pre-planned and strictly defined learning objectives, i.e. not a subjective reality but the objective one (socially established knowledge according to the current level of science development). This, actually, translates into **rectification** of an incorrect knowledge or practice, being achieved carefully, without offending the learner. For consistent constructivism, of course, the discussion during debriefing would simply be considered a **negotiation** among different 'constructs'/theories about reality. This is because there are no theoretical standards. If, supposedly, on a metatheoretical level they could be created, these will also be constructions

and will therefore be perceived differently in the mind of each individual¹⁰! One could say that for each particular case there will be as many different patients as there are doctors. To highlight even more the conceptual difference of SBL and constructivism as its supposed epistemological background, let us note another difference between them: in SBL activities, forms of '**positive**' (good intent) **deception**¹¹ are used in order to **reduce the reality gap** and learners more easily **suspend disbelief**¹², immersing themselves in the event and reacting appropriately as if it were a real situation. Furthermore, deception concerns, on the part of the learners, can be sensibly discussed during debriefing and trust with educators can be re-established. In constructivism, the disbelief in an objective reality, which is exposed by the educators in the pre-briefing and during the SBL event, exists intrinsically, it cannot be suspended, as well as the reality gap, having to do with the 'different realities' that are constructed in the minds of learners (inherent bias); debriefing, based on this theory, can, at best, be understood as a discussion with the aim to reach an agreement between them and the educators.

About causality and the physical laws

Chaos theory¹³ and the Heisenberg's principle of indeterminacy¹⁴ have been used to support –mainly in the field of social sciences– the 'revolutionary' departure from the so called materialistic utopia, i.e. to support the non-existence of underlying laws that determine the evolution of processes in nature (and the knowledge of it). Against the view advocating that these theories support the 'randomness' in the progress of natural phenomena, where humans remain uninvolved and cannot practically intervene, we will support quite the opposite. Firstly, it should be noted that these theories do not disprove causality and determinism. Chaotic behavior was studied in deterministic, dynamic systems as apparently random or unpredictable behavior in systems governed by deterministic laws. Also, for Heisenberg's principle of indeterminacy, it is not true that any result or conclusion that is expected/arises from the application of the probability law is not a conclusion at all. Determinism in natural phenomena, according to classical, Newtonian physics, demands that every phenomenon is determined before its incidence, i.e. every event is predetermined. Thus man becomes essentially incapable of acting effectively and managing his 'destiny'. On the contrary, the introduction of 'probability' to natural laws, of 'sensitivity' to the initial conditions (being the main concept in chaos theory) during the evolution of natural processes– while not negating causality– frees and mobilizes man, making him responsible for their management and outcome; these theories have actually **freed science (and medicine) from fatalism!**

Interestingly, chaotic behavior has been observed in the functioning of biological systems such as the cardiovascular¹⁵ and central nervous system¹⁶, i.e. it concerns medicine and physiology. Still, the causality principle applies. Of course, sometimes things evolve not as desired or predicted e.g. by the doctor for his patient. Again, the fact that the evolution of a biological phenomenon shows great sensitivity to the initial conditions, making the final result not (fully) predictable, may –contrary to what one would expect at first reading– actually, **increases doctor's responsibility** to get informed as best and more as possible about his patient/disease and optimize treatment – in order to uncover and cure an eluding, and possibly very small cause, which being included in the set of factors that determine the progression of the phenomenon, can differentiate it to a critical extent (attractor change!).

Philosophical theories on reality and knowledge: a parallelism with set-theoretical issues

Idealism and Materialism in Philosophy

According to Engels¹⁷ "The great basic question of all philosophy, especially of more recent philosophy, is that concerning the relation of **thinking and being**", or however these have been expressed –idea and matter, spirit and nature, mind or consciousness and objective reality and ultimately which of the two is the primary, the determining and which follows or consequently ensues.

Here, we should perceive matter not as mass but, using Lenin's genius definition¹⁸, as "a philosophical category designating the objective reality which is given to man by his sensations, and which is copied, photographed and reflected by our sensations, while existing independently of them" and even to understand that "the sole 'property' of matter with whose recognition philosophical materialism is bound up is the property of being an objective reality, of existing outside our mind"¹⁹. In the above definition we should not (naively) translate the 'photograph' or 'reflection' of matter (through the senses), referred by Lenin, as a 'mirror image' but as a specific 'interaction' –we could see our senses like the bridge that connects us to the world existing out of our consciousness, of which we are also a part.

Of the various philosophical schools, **materialism** prioritizes (considers primary and determining) the matter while **idealism** the idea, e.g. Plato's world of Ideas/Forms²⁰ and the transcendental idealism of Kant²¹. For both, 'reality' is not accessible to human consciousness but indirectly, through the object for the former and through the subject for the latter (it is not knowable as it 'really exists').

Also, in the history of philosophy, elements that emerge out of the complex interaction of matter with the human mind have been 'isolated', somehow, and have been objectified and absolutized, that is, they have been claimed as being themselves the 'true', undefiled reality. From pure reason (Kant)²¹ to pure experience (W. James)²² (i.e. from the religious essence of reason to the 'innocence' state of Adam and Eve, before the original sin was committed, i.e. before the 'knowledge of good and evil' and any possibility for rational judgments was 'claimed!').

A complete account of the epistemology of all philosophical views is not possible and not within the aims of the present paper. Instead, an attempt will be made to elucidate the way **empiricism** and **constructivism** perceive reality and knowledge about it as opposed to **dialectical materialism**. For empiricists, e.g. for Hume²³, or for Ernst Mach²⁴, reality –all we know about it – consists only of our sensory experiences. Empiricism, in its radical form (phenomenalism) postulates that we cannot reasonably argue with certainty about an objective world existing outside and/or independently of our sensory experiences; it is even questioned whether such an objective reality exists. Our senses are perceived as barriers that separate us from the real world. For constructivists on the other hand, who also base their epistemology only on sensory experiences, "cognition must be considered a process of subjective construction on the part of experiencing organism rather than a discovering of ontological reality"²⁵, i.e. each human, depending on his past experiences, creates his own

reality, as perceived each moment, and there is nothing independent, objective or real beyond this 'construction' that is 'realized' in his mind. This view, if taken seriously and consistently followed, results in pure subjective idealism-solipsism, although its proponents do not consciously and clearly admit it. The relativism of constructivism ultimately renders any concept of science/scientific knowledge as we understand it unattainable. Lenin, in his work 'Materialism and Empiriocriticism', had also reproached Mach for solipsism²⁶; to note, von Glasersfeld²⁷ has considered Mach an ally (i.e. his work is considered a precursor of constructivism).

These philosophical theories, regardless of the starting premise, result in an 'idealistic view' of reality and knowledge and regard **external reality as inaccessible**. On the contrary, dialectical materialism validates external reality, e.g. the way people acquire knowledge about it and act on it²⁸.

Looking for **the essential difference** in the perception of reality and knowledge, between dialectical materialism and the other philosophical theories (which explore the content of knowledge and its relation to reality) we could find it 'hidden' in Lenin's definition of matter, in the sole 'property' dialectical materialism recognizes for it¹⁹: the materialist does not 'create' the reality but **perceives objective reality as external**, i.e. existing outside his mind, becoming the object of his knowledge, in which he seeks or from which he distinguishes universalities, categories, properties and ideas. Other philosophical views set things in the opposite way: they posit as primary a single property, an abstract idea or even an element of the real world, e.g. sensory experiences, and use it as a comprehension principle creating (or characterizing) all reality (and knowledge), i.e. there exists what I know, what I can sense (sets of sensory experiences), there exists what I 'construct' (based on my current and previous sensory experiences and cognitive 'constructions'), or an a priori valid idea/category or rationality, arising from the individual consciousness and being made particular/manifests itself into the concrete objects.

The difference involves the basic distinction of materialism - idealism, concerning what is considered to be the primary/determinant for each of the two philosophical views, the idea or the matter. Giving priority to matter, and then identifying its properties and characteristics, we cannot 'go back' by defining matter through them! That is exactly what the rest of the philosophical views on reality do, apart from dialectical materialism (even the secular ones, i.e. materialistic views that existed before it); they recognize as reality just what they 'consciously perceive' as such, i.e. in fact, 'reject' the idea of a knowable world outside the consciousness and, in parallel with the **Copernican turn** of Kant, they **(re)turn** and, giving priority to consciousness, result in 'arbitrary' generalizations and definitions, in an 'idealized' perception of reality and knowledge about it.

Interestingly, the above can be related to issues that set theory deals with. A brief informative digression would be necessary.

Set theory and the Russell's paradox

During the development of set theoretic basics, initially, to formulate sets, the unrestricted comprehension principle was used, according to which, for any **sufficiently well-defined property**, there is the set of all and only the objects that have that property. In symbols, this principle has as follows:

Axiom/schema of the **unrestricted comprehension principle**:

$$\forall a_1, \dots, a_n \exists S \forall x (x \in S \Leftrightarrow \varphi(x, a_1, \dots, a_n))$$

i.e. there exists a set S whose members are precisely those objects that satisfy the predicate ϕ (ϕ : any sufficiently well-defined property).

Nevertheless, the application of this 'constructive' principle led to contradictions that threatened the foundations of mathematics as a whole, i.e. Russell's famous paradox (1901)^{29,30}:

Let S be the set of all sets that are not members of themselves. **If S is not a member of itself, then it follows, by definition, that it is a member of itself; but if S is a member of itself, then it is not a member of itself, since it is the set of all sets that are not members of themselves.** In symbols:

$$\text{Let } S = \{x \mid x \notin x\}, \text{ then } S \notin S \Leftrightarrow S \in S$$

To avoid the paradox, in 1908, Ernst Zermelo suggested the replacement of this unrestricted comprehension principle by the axiom of selection/separation (Aussonderung)³¹. According to this axiom any condition or predicate (propositional function) can be used to **separate subsets from any given set A** ; i.e., any subset of A , that can be determined using first-order logic, exists. In fact, Zermelo introduced a restriction on the way sets are formed: the restriction allows the association of a set with a given predicate only if this set is an element of another set, whose existence has been already secured by the axioms of the ZFC system (Zermelo-Fraenkel set theory with the axiom of Choice).

The restriction conceived by Zermelo was the following: Let ϕ be a condition on x ; we cannot form the set of all x which satisfy ϕ ; but, if A is a given set, we can form the set of all x in A which satisfy ϕ . Thus, a predicate cannot be used to form a 'new' set, but only to 'select' or 'separate' from a given set A all the elements which satisfy the given predicate.

In symbols, $S = \{x \in A \mid \phi(x)\}$, to be read: 'the set S of all x **in A** such which satisfy $\phi(x)$ '. Thus, Zermelo's theory does not allow directly form the set of all sets endowed with a certain property: $S = \{x \mid \phi(x)\}$, to be read: 'the set S of all x which satisfy $\phi(x)$ '. How the restriction introduced by Zermelo avoids contradictions, i.e., Russell's paradox?:

if, instead of $S = \{x \mid x \notin x\}$, we form $S = \{x \in A \mid x \notin x\}$, then $S \in S$ is impossible, for $S \in S$ implies $S \notin S$, a contradiction! Thus $S \notin S$. It follows that $S \notin A$, for if S were in A , then (because $S \notin S$) we would have $S \in S$, which would be a contradiction. That clearly proves that if A is any set, then the set $\{x \in A \mid x \notin x\}$ cannot be an element of A ³².

Set theoretical parallelism with the different philosophical views

Certain philosophical theories tried to build their epistemological universe in a similar way to which was originally used to build the set-theoretic mathematical universe –by using a conceived concept, which takes the form of a functional proposition, an unrestricted comprehension principle, leading finally to disastrous contradictions. We will take only constructivism¹⁶ –to avoid further confusion– as an example. **Table 1** presents in a concise way important points concerning the foundation of set theory in correspondence with epistemological points of constructivism.

According to Royce³³, even scientific findings "are, in some sense, man-made inventions or constructions" and "the term constructive refers to 'invented' or 'created' (i.e., not

'discovered') theories". **For constructivism, there is no given set of objective entities or a context to which these 'mental constructions' can be referred to.** On the contrary, mental constructions themselves constitute the epistemological universe, the objective reality for each individual.

Von Glasersfeld is revelatory: he states, e.g., in the 'first principle of radical constructivism': "Knowledge is not passively received either through the senses or by way of communication, [rather] knowledge is actively built up by the cognizing subject"³⁴ and also "if we posit causes for the sense data [...], this does in no way entail that these causes exist in the spatio-temporal or other relational structures into which we have coordinated them"³⁵. Finally, von Glasersfeld makes it clear that "those who merely speak of the construction of knowledge, but do not explicitly give up the notion that our conceptual constructions can or should in some way represent an independent, objective reality, are still caught up in the traditional theory of knowledge"³⁶.

Thus, assuming that the answer to the crucial question **'is there or not an objective reality, that is, outside and independent of one's consciousness?'** is negative (or at least not positive), the entire epistemological edifice, as perceived by such philosophical points of view, is 'created' by a more or less complex definition/formula, i.e. it is defined unrestrictedly and arbitrarily, and being so, inevitably suffers from inherent contradictions, which shake its structural stability in the first place⁽¹⁾. Let us see how:

Set-theoretic universe comprises sets and their elements, being sets also. We could perceive the 'constructivist universe' to be sets that contain elements (other sets) having the above mentioned property, i.e. being 'cognitive constructions'. Let us now 'construct' a quite peculiar set A, being a set of all sets with the property of not having the property that the elements belonging to them have (and define them as elements of these sets, i.e. of each of them). Does A have this property (or else is A member of itself)? **If not, it is not member of itself, and, as follows from the definition, it has the property of its members (i.e. not having the property of their members), and it is a member of itself; if it has that property (which its members have, thus it is a member of itself) then it does not have the property of its members (and thus it is not a member of itself):**

$$\neg\phi(A) \Leftrightarrow \phi(A) \text{ or/and } A \notin A \Leftrightarrow A \in A$$

It is obvious that this way of perception and knowledge of reality suffers from an inherent contradiction (**logical antinomies of Russell's paradox**).

To a layman's way of thinking, how is it possible in the context of constructivism to define a concept or a thing? As a set of elements (building blocks, constructs). In this sense, the set A mentioned above does not seem so 'peculiar', since each thing/concept, when defined as a set of elements, will have different properties than the elements it contains –similarly, it's hard to think of an object defined by itself (as it is difficult to think of sets containing themselves).

As Riegler notes³⁷: "The term construction refers to the process by which complex structures are assembled from building blocks. RC (radical constructivism) assumes that there are generally applicable construction rules which

¹The constructivism's propositional function could hold as follows: 'There is nothing but what I construct in my mind, i.e. the property that the elements of reality have is that they are mental constructs'.

are independent from the ontological nature of both the atomic components and the assembled complex structure complex structure, respectively. From a realist perspective cognitive representations are constructed out of objective facts, where constructivists maintain that representations are constructed out of simpler cognitive components". Though, **how can I include these elements in a set** –which involves this concept or thing, since these elements, all together, create/construct it, determine it, identify it as a whole (a particular cluster of them, for example) –, **a priory of its 'construction'**? How do I know that they belong to this set, before it is created by their inclusion? Through their 'random' 'gathering' from the set of all elements of our cognitive universe, which also 'happens' to be (this random gathering of elements) *viable*³⁴⁽²⁾ for the specific property it determines? Similarly, evolutionary epistemology^{7,37} could not interpret, for example, its own biological principles/basic axioms for cognition through the knowledge produced by them, i.e. a priory of cognition, appearing **circular and self-contradictory**; radical constructivism^{7,37} as well suffers from **arbitrariness**, corresponding essentially to an infinite number of cognitive 'constructive' options (we could also see these as a 'tautology' issue, i.e. $a=a$, which ultimately makes the number of existing 'real solutions' infinite).

Looking at it another way, if the set A has this property (not to have the 'properties' that its elements have), which elements of the cognitive universe *cannot be members of it* (let these elements form a set B). There should be elements that have 'some' *properties (being also set elements)* in common with the 'under construction' set A, which of course are not known, as A is not yet constructed –i.e., these properties do not exist as elements of the cognitive universe– and therefore A is empty. There are no such elements in the cognitive universe (i.e., having elements in common with the empty set), and so there is no element in it that does not belong to the set B. Therefore the set B will include itself. Reductio ad Absurdum; we just formed the set of all sets! On the other hand, if A does not have this property (it has the 'properties' of its elements –ergo not a member of itself), no properties exist that could not belong to it a priory of its construction (B is empty); thus A will exhaust the cognitive universe and therefore will include itself.

Von Glasersfeld, realizes actually, the contradiction (that arises by 'defining', in a specific and unrestricted way, objective reality) and finds a way to avoid it, i.e. **by rejecting the idea of an objective world** –that cannot be experienced as such–, and supports his argument by a contiguous question²⁵: "How could the knower's representation ever be said to reflect, or correspond to, or approximate reality if the only access he can possibly have to it is his very own activity of 'knowing'? –we would reach the same 'conclusion' substituting the words 'experience' and 'experiencing' for 'representation' and 'knowing' respectively.

Russell's solution, to avoid the set-theoretic contradiction, was the so-called **theory of types**³⁸: he separated (divided) properties as well as classes into **different logical types**. Thus, according to this theory the classes are formed in a hierarchical sequence: in the first hierarchical level there exist the classes that consist exclusively of **particulars** (first type classes), followed by the second type classes, whose members are the first type classes (classes of classes of particulars/individuals) and so on. It should be noted here that, in order for the theory of types to be adopted it is necessary to refer to the **nature** of the hierarchically different properties and classes, on which their division is based (and therefore the issue of a class e.g. to have itself as a member is avoided). Also, it is important to see that, in this theoretical model, one starts from a definite point, that is, from a set of individual/particular objects, which can be understood as basic arguments of a propositional function.

²Von Glasersfeld in the 'second principle of RC' states: "The function of cognition is adaptive, in the biological sense of the term, tending towards fit or viability; cognition serves the subject's organization of the experiential world, not the discovery of an objective ontological reality".

Interestingly, Riegler, understanding that a problem of **arbitrariness**⁷⁽³⁾ inherently exists in the constructivism's point of view (arbitrary collection of 'cognitive elements/constructs') and in order to deal with it, proposed the existence of **entrenchment**, i.e. a hierarchical interdependence of 'cognitive constructs'; this could be paralleled with Russell's theory of types, as it, similarly, places restrictions on the possible elements that could be included at each level of a hierarchical sequence of 'mental constructions'. Again, we should consider the **nature** of the elements that make up the different, hierarchically interdependent mental constructs, in order to adopt entrenchment and explain their specific evolution. This could be seen as resolving to metaphysical solutions to save an inherently 'unstable edifice' from collapsing.

As noted by Charles C. Pinter³², even Russell's theory of types was not widely accepted by mathematicians; nevertheless, in entrenchment an additional problem arises: in the theory of types it is clear that 'at the beginning' of the hierarchical sequence there are classes of **particulars**, i.e. simple objects to which the propositional function is applied. Retrospectively, **where does** the hierarchical sequence in constructivism's entrenchment **begin**? A concept cannot take itself as argument. If we admit that there may be some 'random', basic 'mental constructions' we return to accepting arbitrariness. Since, for the epistemological universe of constructivism, all objects are 'mental constructions' (this is the concept of constructivism), in case the answer to the question about the existence of objective reality is negative, there would be clearly no elements (**nil**) at the beginning (or the **empty set**, if it is merely not positive – i.e. 'I don't know'). However, 'creation ex nihilo' is the work of God alone; also, the empty set can definitely be used as the fundamental building block for further sets (in fact, the entire set-theoretic universe), but we do not believe that the same can be supported for the cognitive universe of a knowable material world (unless, of course, we deny that such exists).

In fact, since the empty set needs nothing else to exist, one does not need to account for its existence, i.e., its assembling into a whole by other definite elements. On the other hand, the issue of 'unsaturatedness' of concept (concepts are not complete because, as functions, require an argument in order to give a value) is unconditionally addressed since the empty set can be the argument for any concept, i.e., every universal, propositional statement is vacuously true about the empty set. Though, in this way the empty set can generate infinitely many vacuous truths!

In contrast, the materialist view of reality and knowledge does not suffer from such contradictions or intrinsic 'instabilities'. The materialist does not arbitrarily create, through categorizations, sets of real objects, but discovers the category (property, idea) within material reality, 'separates' category (property, idea) (*Aussonderung*), distinguishes it within the real elements which become objects of his research and his knowledge. In the same way, the unique 'property' that Lenin attributes to matter¹⁹, "of being an objective reality, of existing outside our mind", must be precisely seen as the inability of arbitrarily-conceptually using any category/property (even this very unique 'property') to characterize the matter as a whole, to narrow it down to something. Mathematically, we could cite as a corresponding 'principle' the non-existence of the set of all sets.

Reality and knowledge cannot be fitted into any neat a priori schema. Marx, in his theses on Feuerbach³⁹ in fact criticized the way materialism dealt with reality before the integration of Hegelian dialectic into it, that is, before the appearance of scientific (dialectical) materialism.

³The concept of arbitrariness in constructivism's epistemology may in fact indicate the existence of an unrestricted principle since it essentially means that the 'construction' of the cognitive elements is not limited/restricted by something.

Mechanical materialism ignores kinesis of matter; abstractly takes a **concept of 'materiality'** and turns it into an absolute category of the objective-real world, 'idealizes' the way we perceive reality and knowledge. Feuerbach⁴⁰ was also materialist. Nevertheless, he argued that there was an abstract, universal model of the human essence (an authentic/inherent essence of humanity). Marx disagreed with his view of humans as unchanging; real humanity would not express itself in religious terms. In his theses on Feuerbach Marx noted³⁹: "**I.** The main defect of all hitherto-existing materialism — that of Feuerbach included — is that the Object [der Gegenstand], actuality, sensuousness, are conceived only in the form of the object [Objekts], or of contemplation [Anschauung], but not as human sensuous activity, practice [Praxis], not subjectively. ... **IV.** ... His work consists in resolving the religious world into its secular basis. ... the secular basis lifts off from itself and establishes itself in the clouds as an independent realm... **VI.** Feuerbach resolves the essence of religion into the essence of man [menschliche Wesen = 'human nature']. But the essence of man is no abstraction inherent in each single individual. In reality, it is the ensemble of the social relations.... The essence therefore can by him only be regarded as 'species', as an inner 'dumb' generality which unites many individuals only in a natural way."

Finally, it would be interesting to note what, in his article on Russell's paradox, Bernard Linsky states⁴¹: "If a set must be a collection of definite objects and a set is determined by its members, it cannot be 'definite' before it is collected; thus, no set can be a member of itself. But then 'the sets that are not members of themselves' would be all sets, and this is clearly not a definite 'collection', able itself to be formed into a set. Thus, the putative '**Russell set**' is **not a consistent multiplicity**, and no one should be surprised that there simply is no such set".

Thus, dialectical materialism, by analogy with Zermelo's correction for 'Russell's set', might be said to hold unacceptable the inclusion, in a part of objective reality, of the wholeness of the objects of reality. Trying to limit infinite matter to something or ignore its perpetual motion, one will simply wander in the contradictions of his own constructs.

Concluding this treatise some verses of the Greek Nobel laureate poet George Seferis are quoted:

I want nothing more than to speak simply, to be granted that grace. Because we've loaded even our song with so much music that it's slowly sinking and we've decorated our art so much that its features have been eaten away by gold and it's time to say our few words because tomorrow our soul sets sail.

George Seferis (1900-1971), An Old Man on the River Bank

Cairo, 20 June 1942

Source: George Seferis: Collected Poems (Princeton University Press, 1995)

Conflicts of interest

None declared.

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Table 1. Constructivism epistemology: a parallelism with set-theoretical issues

Set theory		Epistemology (constructivism)	
Points in set theory		Corresponding points in epistemology	
Definition of sets, parts of the set-theoretic universe	Unrestricted comprehension principle (Cantor)	Definition of sets, parts of the epistemological universe-reality (according to constructivism)	Specification of the unrestricted comprehension principle in radical constructivism: everything that exists as an element of the above sets is a mental construct
Predicate (leading to Russell's paradox)	<p>Let S be the set of all sets that are not members of themselves. If S is not a member of itself, then it follows, by definition, that it is a member of itself; but if S is a member of itself, then it is not a member of itself, since it is the set of all sets that are not members of themselves. In symbols:</p> <p style="text-align: center;">Let $S = \{x \mid x \notin x\}$, then $S \notin S \Leftrightarrow S \in S$</p>	Predicate (leading in a variant of Russell's paradox)	<p>Let A be the set of all sets with the property of not having the property that the elements belonging to them have (and define them as elements of these sets, i.e. of each of them). Does A have this property (or else is A a member of itself)? If not, it is not a member of itself, and, as follows from the definition, it has the property of its members (i.e. not having the property of their members), and it is a member of itself; if it has that property (which its members have, thus it is a member of itself) then it does not have the property of its members (and thus it is not a member of itself):</p> <p style="text-align: center;">$\neg\phi(A) \Leftrightarrow \phi(A)$ or/and $A \notin A \Leftrightarrow A \in A$</p>
Comments	What could Russell's set (which led to the well-known paradox) represent conceptually, in the context of set theory (the set of all sets, elements of the set-theoretic universe: "If a set must be a collection of definite objects and a set is determined by its members, it cannot be 'definite' before it is collected; thus, no set can be a member of itself. But then 'the	Comments	What could a constructivist's set A represent conceptually, in the context of set theory* [Following Linsky's ⁴¹ way of thinking, if a mental construct must be a collection of definite objects (being mental constructs also) and the mental construct is determined by its constituents, no mental construct can be definite before it is formed; thus, no mental construct can be a

	sets that are not members of themselves' would be all sets, and this is clearly not a definite 'collection', able itself to be formed into a set. Thus, the putative 'Russell set' is not a consistent multiplicity, and no one should be surprised that there simply is no such set" ⁴¹ .)		member of itself. But then, mental constructs that are not members of themselves would be all mental constructs, and this is clearly not a definite collection of mental constructs, able itself to be formed into a specific mental construct. Thus, the constructivist's cognitive universe (set A) is not a consistent multiplicity, and one could reasonably conclude that such a construct does not really exist.]
A way to avoid contradiction	Russell's theory of types ³⁸ [though: this is not a 'structural' restoration, it concerns the different nature of types (metaphysics)]	A way to avoid arbitrariness/logical antinomies	Entrenchment ⁷ (hierarchical interdependence of 'cognitive constructs')
A basis of the set-theoretic edifice	An initial 'particular', different from the types that follow the sequential application of the propositional function	A basis of the epistemological edifice	Initial argument (?): \emptyset (or nil)
Definitive way of avoiding paradoxes-contradictions	Different way of defining-creating sets according to Zermelo: there is an independent/given set from which we distinguish/separate elements with specific properties (Aussonderung)	Definitive way of avoiding paradoxes-contradictions or a realistic way of perceiving reality and our knowledge of it	Dialectical materialism: there is an objective – independent of our consciousness – reality, from which we separate elements with specific properties, or in the elements of which we distinguish specific properties (Aussonderung)
*Assuming that all its 'cognitive elements' are arbitrary mental constructs that have no objective knowable basis.			