The Cost of Science

Gennady Shkliarevsky

We live in a rapidly changing world and the pace of change is accelerating. Technological progress is one of the most dynamic areas that is transforming our society. The influx of new technologies boosts productivity. It increasingly replaces human labor in performing routine repetitive mental or physical tasks and frees humans for creative work.

The increasing emphasis on creativity affects many spheres of our lives and makes us rethink the practices we use. In reviewing our practices we ask whether our current practices are good enough, whether they are efficient and meet the needs of modern society.

Science is one of the areas of particular importance in today's world. Our curiosity about nature used to be the main reason for our pursuit of science and in many ways it still is. However, due to expanding knowledge and a creative economy, science is increasingly becoming an important factor in our economic production. Given the fact that modern science requires substantial resources, we expect science to contribute directly and systematically to our economic progress, to solve various problems we face, and improve social wellbeing. For this reason, the issue of efficiency is increasingly relevant to science as much as to any other economic enterprise and it deserves the most attention.

Our current science practice has its roots in the tradition of the Enlightenment that originated more than two hundred years ago. Science has greatly changed since that time. However, despite all the changes, the intellectual foundation of our science practices remains basically the same.

Knowledge is central to the Enlightenment tradition which considers the quest for knowledge fundamental to human existence. According to this tradition, knowledge acquisition represents the mission of humanity and the fulfillment of its destiny. The Enlightenment rejected religion and metaphysical speculations and proclaimed a systematic study of nature as the only possible path to true knowledge. In order to achieve true knowledge, the study of nature–or the science practice–should rely on rational analysis, observation, and experimentation. These fundamentals of scientific research are as valid today as they were back in the 18th century.

A serious rethinking of our science practices requires a critical examination of its premises and the questioning of the very truths that we accept as self-evident. Is knowledge acquisition as fundamental to our existence as the Enlightenment tradition has it? Are empirical data a reliable criterion for validating knowledge? Serious analysis is not possible without posing these questions.

According to our current scientific practice, the essential ingredients of scientific truth are a theory based on rational analysis and empirical facts that support this theory. We understand rationality as the capacity to construct statements that provide logical explanations of causal relations.

Empirical support—that is, the establishment of a one-to-one correspondence between theory and facts—turns theoretical statements into scientific truths.

Both rational explanation and empirical verification are equilibrating operations. Rationality brings our mental constructs in balance with each other and empirical verification correlates our mental constructs with facts we observe in nature. We also associate equilibration and balance with continuity. By claiming that what we understand as knowledge is the main goal of science, we essentially recognize equilibration as the primary operation in the production of knowledge. The recognition of equilibration as the main organizing principle of our science practice also assures continuity.

Yet knowledge acquisition involves new discoveries. Discoveries are disruptive. They represent a break with the past or discontinuity. The fact that a scientific discovery involves discontinuity suggests that the production of disequilibrium is an essential part of our scientific exploration. Discontinuity and disequilibrium are two properties that we associate with the creation or the emergence of something radically new that did not exist prior to its emergence. Thus the production of knowledge involves an act of creation.

Novelty, particular radical novelty, requires a capacity on our part to perceive new possibilities or new properties. In order to be able to perceive new possibilities or properties, we need mental constructs that have sufficient power to allow such perceptions, and more powerful constructs are possible only on the basis of new and more powerful levels of a mental organization. The inclusion of differences is the source of new and more powerful levels of organization.

The current science practice relies primarily on consensus. Consensus is a very common approach in validating scientific theories. Consensus is primarily about conformity, not disruption. Consensus pays little attention to differences and seeks to either minimize them or ignore them altogether. As a result of its orientation toward consensus, our current science practice is not particularly conducive to new discoveries and fundamental theoretical shifts.

This is not to say that discoveries and shifts do not occur. However, they are not due to the existing practice but rather occur in spite of it.

In other words, our science practice is not efficient. It tends to underutilize those resources —operations and procedures that focus on the production of disequilibrium and discontinuity— that are essential for major shifts, for rethinking fundamental premises and theories, and for scientific progress in general.

As has already been stated, the principal source of new knowledge is the emergence of new and more powerful levels of mental organization that have not existed prior to their emergence. What is the source of the rise of new levels of organization? Why do we create them?

The source of creation is conservation. Conservation is not a product of human intellect; it does not originate in conscious and rational choices and decisions. Conservation represents an unconscious drive that has its roots in the evolution that preceded the rise of humanity.

Conservation is ubiquitous throughout our universe and is due to its unique nature. Our universe is all there is; nothing comes into it from outside and nothing can disappear from it. Everything must be conserved.

Conservation is much more fundamental to our existence than consciousness, rationality, and knowledge. This is not to say that consciousness, rationality, and knowledge are not important. They are. But they are not primary to our existence. They have emerged from the evolution that has its roots in conservation; they are products of the process of creation without which conservation would be impossible. The process of creation is fundamental to our existence.

Human intellect is a product of evolution that is rooted in the process of creation. It is the most powerful form of organization of reality. Human consciousness is capable of constructing an infinite number of new and increasingly more powerful levels and forms of organization. If we establish conscious control over our capacity to create, we will use this capacity more efficiently. The efficient use of this capacity is very important for our science practice.

Our current science practice was established a long time ago. Our civilization was then at a very different stage in its evolution. Much has changed since that time. Our civilization has evolved a great deal: we produce more, we know more, and we have capabilities that are immeasurably more powerful than those available to our predecessors. It is time to modernize our science practice and make its organization more efficient. Our science practice should foster, not hinder the process of creating new and more powerful levels and forms of organization.

The efficiency of our science practice vitally depends on understanding the process that makes knowledge possible. Knowledge and understanding are not central to this process; they are merely its products. This process is about including differences and creating new and more powerful levels and forms of organization. For this reason, we should use the inclusion of differences and creation as the main organizing principles of the new science practice. Inclusiveness, not empirical validation or rational justification, should be the main criterion in validating knowledge.

Much of our current science practice is about the establishment of one-to-one correspondence between our theories and facts of reality. The view that considers one-to-one correspondence to be the essence of our scientific enterprise orientates our science practice toward equilibration and gives little recognition to a very important aspect of the process that leads to discoveries—the production of disequilibrium.

The privileging of equilibration has several negative consequences for our science practice. For one thing, the validation of knowledge based on one-to-one correspondence is not a particularly reliable procedure. Mental constructs represent the most powerful level of organization of reality. The range of possibilities that this level of organization offers is far broader than that of any other

level of organization in nature. That is the reason why we can explain natural phenomena. On can always establish correspondences between mental constructs and reality. There are many instances when the same empirical observations fit radically different and even discordant theories—a phenomenon we call underdetermination. Also, many theories in the past that agreed with empirical observations and had practical use were subsequently proved to be wrong. Think about Ptolemy's geocentric theory of the universe or the aether theory of light that enjoyed great currency in their days only to be discarded later as wrong.

However, and even more importantly, the preference for equilibration privileges established theories as opposed to new perspectives. Establishing one-to-one correspondence is a costly and time-consuming procedure. Theories that are already recognized enjoy enormous advantages over new perspectives. They have already accumulated experimental data that are used for their validation; many scientists have vested their careers and interests in these theories. In the world of limited resources, new perspectives face the formidable task of conducting experiments (that are often costly), collecting empirical evidence, and gaining converts. They are also at an enormous disadvantage by comparison with established theories in attracting resources.

Privileging established theories underutilizes our capacity to create. This capacity is the only resource we have that appreciates when used. Failure to utilize this resource devalues and wastes it. The moment we stop creating, products of our thought begin to depreciate, just like a new automobile that we buy depreciates as soon as we buy it. The value of theory also declines, even if the currency in which we measure this decline in "price" is different.

The view of knowledge as the main goal of our science practice is a product of the logocentric tradition of the Enlightenment that places reason and consciousness in the center of our worldview. It is a very limited perspective that fails to appreciate the process that makes our scientific exploration possible. Without the process of creation science simply would not exist. Sustaining this process is essential for our science practice and, therefore, should be its main goal.

Conservation requires access to new resources, which makes constant creation a must. The rise of new and more powerful levels and forms of organization provides access to new resources, thus countering the effects of entropy production. We cannot change the law of entropy that says that entropy production can never be less than zero. But with the help of the process of creation, we can maintain entropy production at zero. There is nothing in the law of entropy that prohibits this possibility.

In order to succeed in maintaining such zero levels of entropy, our science practice must be very efficient in utilizing the human capacity to create. Its principal goal should be to maximize this capacity, not constrain it. Therefore, sustaining the process of creation and advancing its evolution, not protecting existing theories, should be imperative for our science practice. We should organize our science practice around this process. Inclusion of differences, not search for consensus, should be its main operational principle, and inclusiveness is its main criterion for validating knowledge. The more inclusive our knowledge is, the more differences it integrates, and the more powerful and

the more valuable it is. This is not to suggest that the current criteria of rational justification and empirical verification are not important; they most certainly are. However, they are to complement, not replace, the criteria associated with the process of creation.

The role of science in our society is growing. Today's science is an important part of our economic production. It requires substantial resources and capital. The cost of many scientific projects today is quite comparable to major projects in any other branch of the economy. Projects such as the Large Hadron Collider (LHC) or the exploration of outer space require mega-billion dollar investments. Without efficient science practice, these investments may not necessarily lead to real progress. For example, despite significant investments in fundamental physics (the cost of LHC, for example, is $13.25 billion and its operating budget is $1 billion a year) there have been no significant and fundamental theoretical breakthroughs in physics since the formulation of quantum mechanics and theory of relativity—and that was almost one hundred years ago. The anomalies that our physicists cannot explain—such as dark energy or dark matter— continue to accumulate. Our view of physical reality remains divided into two largely separate pictures—one supplied by quantum mechanics and the other by the theory of relativity—with little prospect for unification. Yet we continue to rely on old and tired theoretical approaches.

Today, science is more important than at any other time in human history. We no longer view science as merely a way to satisfy our curiosity. We expect science to contribute directly to our economic progress and to the general wellbeing of our society. Simply doing science today is not enough. We no longer live in the world where costs associated with science were insignificant; and where the role of science in production was so negligible that the issue of cost did not even arise. That is no longer the case. Today, inefficient science practice is just as costly, if not even more so, as inefficient management of the economy. The cost of inefficiency in science is not merely in dollars and cents; the real price of the inefficient practice is the stagnation of science.

If you're interested in writing for International Policy Digest - please send us an email via submissions@intpolicydigest.org