2023, November

Introduction to Scientific Method Seminar
(Understanding the Science. One vision)

Second part. Reflections and practice

This seminar is for thinking, not for recipes.
I would like to shake up some myths and arrogance of science**.**

Reflections about

Summary

Reflection One. Positioning

We often think that the immediate world around us is The World. Later, some of us discovered that this is not the case. Therefore, the first reflection must be to clarify the positioning of the Seminar, where we are, because its discourse is influenced by this condition. Honesty is important.

Behind Science there is not always science. Long before technology and science were born, each human group, each human being, built a vision of their world: place and time. On this vision, human beings have built everything else, including science.

From that perspective it is convenient to determine where we are, what its history is, because this will be (consciously or unconsciously) behind the ideas presented in the Seminar. Science is not aseptic because it is a human construction.

Concretely, we are in the West. For example, for me and other people:

> Lebanon is in the Middle East.
> China is in the Far East.
> Russia is far away, but it is not the East, because it is Europe,

> and Europe is classified as the West, although there was a Western Europe and an Eastern Europe.

Briefly, the West is what has Christian roots. The West is a culture, not a geographical position. *'Culture is what remains after forgetting what was learned.'* [André Maurois]. You can be an atheist and have a Christian, Islamic, Buddhist culture... I am an atheist and I have no scientific reason to be.

The Seminary belongs to the Western culture. Almost all the authors cited in the main book of the Seminar (What is this thing called Science?) are from the West. Therefore, it expresses a Western vision of science. Me too. But it is not the only vision of science, nor the best. So, the Seminary does not have the Truth. It states a point of view, one more of those that exist in our infinite World: Chinese, Islamic, Hindu, Buddhist, Bantu, Mayan, …

The Seminar view will also be biased by countless other factors (policy, economy, ...). The Seminar is about understand Science from a Western perspective with its visible or invisible prejudices and its conditions. Then, you must build your own criteria.

Summarizing. The Seminary belongs to the Western culture, it does not have the Truth. Then, you must build your own criteria.

Reflection Two. Science and Technology

Our context (**software**) is fundamentally technological, although sometimes we do science. The Seminar is aimed at this last activity, Science. We will begin by differentiating both activities given the confusion that can occur due to the frequent interactions between them today. It is important to distinguish that they have different objectives, paths, and tests.

SCIENCE	TECHNOLOGY
(**discover**)	(**build**)

Science

the essence of the seminar

A dictionary says:

> *knowledge or a system of knowledge covering general **truths**, or the operation of general laws especially as obtained and **tested through scientific method**.* [Merriam-Webster].

According to the preceding text, in science the aim is to achieve truths. **Truths**!
Is this valid for technology? No, it is not.

Technology

The technology is different. Their goal is to build useful things, not to seek the truth. Technology wants something more direct and tangible than the truth. And it is tested in another way. Let's see.

Example of a technological test. Charlot Eating machine.
https://www.youtube.com/watch?v=_OKs2MWaBcA

How old is today

Behind technology there is not always science. In fact, technology was born long before science. And today technology has a legacy of ancient technology. For example.

> ***The US standard railroad gauge (distance between the rails) is 4 feet, 8.5 inches!***
>
> *That's an exceedingly odd number.* ***Why was that gauge used?***
>
> *1) Well, because that's the way* ***they built them in England****, and* ***English engineers designed the first US railroads.*** *Why did the English build them like that?*
>
> *2) Because the first rail lines were built by the same people who built the wagon tramways, and that's the gauge they used. So, why did 'they' use that gauge then?*
>
> *3) Because the people who built the tramways used the same jigs and tools that they had used for building wagons, which used that same wheel spacing. Why did the wagons have that particular odd wheel spacing?*
>
> *4) Well, if they tried to use any other spacing, the wagon wheels would break more often on some of the old, long-distance roads in England. You see, that's the spacing of the wheel ruts.* ***So, who built those old rutted roads?***
>
> *5****) Imperial Rome*** *built the first long distance roads in Europe (including England) for their legions. Those roads have been used ever since. And what about the ruts in the roads?*
>
> *6) Roman war chariots formed the initial ruts, which everyone else had to match or run the risk of destroying their wagon wheels. Since the chariots were made for Imperial Rome, they were alike in the matter of wheel spacing. Therefore, the* ***United States standard railroad gauge of 4 feet, 8.5 inches is derived from*** *the original specifications for* ***an Imperial Roman war chariot****.*
>
> *Bureaucracies live forever. So, the next time you are handed a specification/procedure/process and wonder 'What horses as came up with this?', you may be exactly right.*
>
> *7) Imperial Roman army chariots were made just wide enough to accommodate the rear ends of two war horses. (****Two horses' asses****).*
>
> *Now, the twist to the story: When you see a* ***Space Shuttle*** *sitting on its launch pad, there are two big booster rockets attached to the sides of the main fuel tank. These are* ***solid rocket boosters, or SRBs****. The SRBs are made by Thiokol at their factory in Utah. The engineers who designed the SRBs would have preferred to make them a bit fatter, but the SRBs had to be shipped* ***by train*** *from the factory to the launch site. The railroad line from the factory happens to run through a tunnel in the mountains, and the* ***SRBs had to fit through that tunnel****. The tunnel is slightly wider than the railroad track, and* ***the railroad track,*** *as you now know****, is about as wide as two horses' behinds.***
>
> *8) So,* ***a major Space Shuttle design feature****, of what is arguably the world's most advanced transportation system,* ***was determined over two thousand years ago by the width of a horse's ass.***

[taken from **NatureQ**
opernstdoSh4uur:a1tg elt lt m44l0m1t1eai4gu80912 06c1 om13sdb ·]

Despite the role that horse assess play in today's railway and aerospace technologies, some dictionary says:

Technology

- *The application of scientific knowledge for practical purposes, especially in industry.*
- *machinery and equipment developed from the application of scientific knowledge.*
- *the branch of knowledge dealing with engineering or applied sciences*.

[Oxford Dictionary]

The above description of technology connects technology with science as if technology were not possible without science. This can cause confusion and approach technology (our primary context) as if it were science or applied science. But the overhead story (gauge) shows that technology should not be defined in terms of science because both are different activities, although today, they often support each other.

Technology is the distance between the rails determined by the horses' butts. Technology is the mastery of fire and the flint ax that preceded science by more than a million years.

Another dictionary describes the technology more closely to the domain of fire, flint axes and even the butts of horses. So, I could take it as a reference if I will need it.

Technology
1.
a: *the practical application of knowledge especially in a particular area.*
b: *a capability given by the practical application of knowledge.*
2. : *a manner of accomplishing a task especially using technical processes, methods, or knowledge.*
3. : *the specialized aspects of a particular field of endeavor.*
[Merriam-Webster Dictionary]

Summarizing. Science is concerned with discovering truths while technology is concerned with building useful artifacts. Science and technology are different fields although they often interact today. The scientific method is a test for science, not for technology. It is advisable to take this fact into account in our respective work and publications. Today, no matter how new it may seem, is frequently affected by an ancient and forgotten legacy.

Reflection Three. Truth

The beginning description of Science is simple. Science is a Truth tested by the Scientific Method.

The before description of science is useful for distinguishing it from technology and it is enough for the public. But, not for us because Truth and Scientific Method are controversial concepts.

Let's beginning with the Truth concept. Dictionaries have several definitions of Truth, but none is the true of the Truth, because they are only definitions (agreements for the use a word or phrase in some sense).

Let's take the Royal Academy of the Spanish Language.

> **Truth** (Verdad in Spanish)
> *1. f. Conformity of things with the concept that the mind forms of them.*
> *2. f. Conformity of what is said with what is felt or thought.*
> *3. f. Property that a thing has of always staying the same without any mutation.*
> *4. f. Judgment or proposition which cannot be rationally denied.*
> *5. f. Quality of truthful.*

So, Truth could be:

> the Truth that a mother, with her sick son, looks for in medicine and, also in God when she prays to save her son. (*Trust in Science and in God simultaneously*).
> the Truth that an artist expresses in his painting, sculpture, music, ... (*The artist truth*).
> the Truth that sentences a person to jail. (*Truth by agreement*).
> the Truth of the person who interprets a sound. (*Truth of an interpretation*).

But there is no reference regarding the Truth of Science.

This truth is associated with another elusive word: reality, which pretends to be objective, i.e., independent from the observers. Therefore, a universal truth, for everyone.

However, considering the previous analysis, I must accept the reality of Medicine, the reality of God, the reality of the artist, the reality of the justice, … They are all there. They are tangible. It is possible to live or die for them.

I recommended you, for example, see these books referenced in the bibliography*: 'Einstein's Space and Van Gogh's Sky [7]', 'How Real Is Real?' [8], also the Japanese picture 'Rashomon' de Akira Kurosawa.*

The Oxford Dictionary does directly relate Truth and Reality. In addition, it stands out a relevant criterion: Truth by acceptance or agreement and associates it (casually?) with scientific truths.

- the quality or state of being true.
  "he had to accept the truth of her accusation"

- that which is true or in accordance with fact or reality.
  noun: **the truth**
  "tell me the truth"

- a fact or belief that is accepted as true.
  plural noun: **truths**
  "the emergence of scientific truths"

Summarizing. Up to this point I must accept that there is a diversity of truths, sensitive to place, moment, person, and agreements. When you publish a scientific paper, you are proposing a truth. But What Truth is a Scientific Truth?

Reflection Four. Influences on Truth in Science

Truth is not an exclusive quality of Science. Long before Science, Faith was a Truth and remains so until now. Later, Art was and is also a Truth. And recently Science has been and is a Truth. Many of them argue (even fight) to be the only Truth, the true Truth.

Faith

Faith (in God or Gods) is a personal Truth, associated with a Worldview, to live beyond Death in some way. It is often a revealed Truth, unique, absolute, [*I, the Lord your God, am a jealous God (Exodus 20:5, Bible)].* infinite, and immobile. To know these properties of Truth of the Faith is very important because they are projected on other Truths, as underground reflections of Faith.

Not all of us have that Truth (in any God or Gods), but it is a reality for those who do. The father who invokes the doctor and God to save his daughter.

That reality may be such that some people can kill and die for that Truth (in any God or Gods) and other Truths (policy, …), all of them personal truths.

It could be said that Faith is a way of feeling and seeing the world and even of living. It is a human face. '**Admit the existence of man, implies admit the existence of the divinity** like the creator of man or like a created from man.' [Wagensberg [22]]

As we will see later, Western Modern Science was born from Faith and coexists with Faith, although with disagreement (Who has the true). Weinberg [4] said. '***Science does not explicitly deny the divinity****. His audacity is at most on the tacit assertion that the* ***gods are dispensable*** *to access the intelligibility of a few parts of the world.'*

In other cultures, the sciences have also been born from Faith associated with culture and their coexistence is maintained. Science has been populated by believing scientists since its origins. The list is endless.

No science (even the proclaimed atheistic one) is free of its cultural background, where Faith is a part.

Art

Art is related to sensations, feelings, and emotions. Like Faith, Art is another **holistic** part of the human being. And scientists are human. **There is no emotion-free reasoning**. *["Descartes' Error. Emotion, Reason, and the Human Brain" Antonio Damasio[6]].*

Art has been and is one motor of scientists. The beauty of a phenomenon, the beauty of a theory, ...

`*When you find a beautiful theory, you experience the same emotional reaction that you feel when faced with a work of art.´* [cited in Lost in Math. How beauty confuses physicists. (book referred to in the bibliography [25]). Although, the author of the same book rebels against this trend and writes: '*Creating works of art is a respectable craft but science is not an art*.' However, the trend persists because art is a human face.

Art, like Faith, are present in Science because those who do Science are subject to emotions, feelings, like all humans. Non-Faith is also a belief, a Faith. I have this belief without resorting to science to justify it.

Returning to Art, to beauty.

*'That is why there is for me a fascinating relationship between art and physics; the art innovative is also a new **way of seeing**, a new way of looking at the world.' (Lewin, physical)*

*'The true beauty of an innovative work of art, regardless of how ugly it is, is in its **meaning**.' (Lewin, physical)*

Finally, an often criterion used in science:
'The **beautiful** *is the **true**.'*
Humberto Eco 2010

Beauty has been a criterion for choosing one theory or another, and also a motivation for seeking an explanation, although there are protests against.

I have chosen some opinions about art because of their relationship with the themes of the Seminar. Nature, God, Science, Truth is present. It doesn't matter if they belong to the cited author, fake or not someone has thought of them.

According to
http://the-creative-business.com/what-is-art-30-famous-definitions/[1]

I have kept the numbers from the original list.

1. *'Art completes what nature cannot bring to a finish. The artist gives us knowledge of nature's unrealized ends.'*
(Aristotle, 284-322 B.C.)

2. *'Art is the Queen of all sciences communicating knowledge to all the generations of the world.'*
(Leonardo da Vinci, 1452-1519)

3. 'The true work of art is but a shadow of the divine perfection.'
(Michelangelo, 1475-1564)

4. *'Art is everywhere you look for it; hail the twinkling stars for they are God's careless splatters.'*
(El Greco, 1541-1614)

18. *'Art has absolutely no existence as veracity, as truth.'*
(Marcel Duchamp, 1887-1968)

21. *'Art is science made clear.'*
(Jean Cocteau, 1889-1963)

22. *'Art is not a mirror held up to reality, but a hammer with which to shape it.'*
(Karl Marx/Berthold Brecht, 1898-1956)

23. *'Art is magic delivered from the lie of being truth.'*
(Theodor W. Adorno, 1903-1969)

The following image reflects a painting by Matisse located in the Museum of Modern Art in New York. It was interesting when I saw it, because it is an interpretation (his interpretation, his truth) of a portion of the world at a given moment (the window of the artist's home).

Composition 1915. H. Matisse

MoMa

Although Matisse's title for this canvas accentuates its abstractness, notes taken during a 1931 interview with the artist indicate that it represents a view from a curtained window in the artist's home, including the blue glass canopy that covered the front door:

"The curtain was red, the color of the yellow [represents its] lining and the pattern [was] added by the artist. The green frame of the window suggests the green of the trees outside and the cool contrast of the green of the trees and the blue sky necessitated the large mass of yellow which to the artist signifies the vibration and pleasure he derived from the contrast of trees and sky. It is not therefore a completely abstract picture but a picture which has its roots in reality."

Gallery label from 2011.

Art expresses the personal artist truth. A truth diverse, relative, finite, and mobile. A truth different from the Faith (unique, absolute, infinite, and immobile), but compatible with it, also with Science.

It could be said that Art (like Faith) is a way of feeling and seeing the world and even of living. Things that humans cannot ignore. They are there.

Summarizing. The Truth associated with Faith is unique, absolute, infinite, and immobile. The Truth associate with Art is relative, finite, and mobile. Both are personal truths compatible with each other and with science. Faith and Art can be motivations and criteria (explicit or implicit) for scientists. Western Modern Science was born from Faith and coexists with Faith. No science (even the proclaimed atheistic one) is free of its cultural background, where Faith is a part, although some deny it.

Reflection Five. Modern Western Science

The current distance between train tracks is not the only one that has a historical origin. Current Science also has a historical origin, the so-called Modern Western Science, born in the 17th century. In both cases with a very strong legacy.

The assumptions of Western Modern Science have lasted for several centuries and are still valid, but they began to change in the late 19th century. We will take a trip back in time to see the origin and evolution of those seminal Truths of Science.

I will begin with the birth of Western Modern Science (17th Century) and then move on to Contemporary Science (present).

> In **software** term it is a travel from Waterfall model for software development to Agile approach. The Waterfall model expresses the worldview of Western Modern Science (Century XVII) whereas Agile expresses the worldview of Contemporary Science (Century XX and after).

It may be surprising that the assumptions of Modern Western Science coincide exactly with the Cartesian assumptions in proving the existence of God.

Around the seventeenth century, Faith was (and today is) a transcendental Truth, something that has no relation to reason. For Blaise Pascal (1632-1662), the rational arguments used to demonstrate the existence of God are useless and irrelevant and for this reason he proposes that God be understood through faith.

However, Descartes set out to prove that God exists. Faith using reason. That is, God not only exists within me, but God also exists outside of me, and it is possible to prove it.

The Cartesian line of thought to prove the existence of God harmoniously connects (justify) all those seminal Truths of Science!

Descartes had to make several simplifications (assumptions) to justify his ideas.

- **First.** Descartes assumed a distinction between inside of me (subject) and outside of me (objects, (Nature)) by **splitting the subject from the object** (simplification by dissociation).

- **Second.** Descartes assumed the Truth of God (existence) is demonstrated through the Truth of the Object (the world outside me) that God has built. God exists because he manifests himself in nature, not because I believe in him.

  The Truth of God is expressed in the Truth of objects (Nature), a Truth Unique, Absolute, Infinite and Motionless because it reflects divine perfection.

  Origin of Modern Western Science

  So, **the Science was a look at the World (external to subject) to confirm the Faith!**
  A look at objects independent of the subject (a look today called objective) that proves the existence of God.

  Science had access to the Truth, which until then had only been the property of Faith. **This Truth gave to the Science authority, power**, **arrogance**, ... Often, **science is taken as divine.**

From here, the Found Truth and the Revealed Truth began to compete for what is beyond, for the universal, although the origin of the Found Truth was to confirm the Rebelled Truth.

Therefore, Science has sought universal laws, initially to express the universality of God. But later it has maintained that objective, ignoring what is particular (an individual item). Today that vision is restrictive because the study of the individual provides important knowledge for its own value and its usefulness. There are truths in the general (Plato) and in the individual (Aristotle).

Science and Faith can be separated or together, it is something personal, a matter of freedom.

- **Third.** Descartes needs that the Truth of objects is always attainable so that the Truth of God can be reached, because the demonstration of the Truth of God is based on that Truth. If I cannot be certain of the truth of the object (nature) I cannot demonstrate the truth of God.

Determinism

Then, Descartes postulates (assumed) that "*there is nothing so far distant that one cannot finally reach nor so hidden that one cannot discover*." [Discourse of the Method].

In short, Descartes tells humans that **they can always get the truth from the world of objects.** He needs this postulate (this assumption) for his demonstration of the Truth of God, but it is an arrogant postulate because it equates humans with God. Anyone can reach the truth (a democratization of the Truth).

Uncertainty was an obstacle to reaching the Truth that should and could be removed. The assumption of uncertainty should be removed implies uncertainty is not an essential of the World: **uncertainty is only an accident**.

He restricts the look to world ignoring uncertainty as (inevitable) essence of the world. Without this simplification, the Truth of objects could not be reached and the path to the Truth of God would be interrupted.

- **Fourth.** The Descartes, with the previous simplifications as support, proposed a tool for reach the Truth thought the reason: **The Method**. In this way Descartes complete the previous idea: Anyone can reach the truth … following The Method. In other words: Descartes assumed **The Method is the way to reach the Truth**.

Summarizing. The initial assumptions of Science coincide with the assumptions to prove the existence of God**.** Science has been linked to Faith since its origin. The initial assumptions were: The separability of the object from the subject; the Truth is Unique, Absolute, Infinite and Motionless; Truth is knowable, uncertainty is eliminable (determinism); The Method is the Way to the Truth. When Science had access to knowledge, it became powerful and for some it became Divine, replacing God.

Reflection Six. The Method

Since the 17th century, the Method has been assigned a primary role, often supreme in many cases. Software Engineering is a good example, in our context, of the supreme role of Method**.**

> The Waterfall model (for building **software**) copies the Cartesian Method. As in the case of horse butts and train lines, the past is present today.
>
> **Cartesian Method [2]**
> *'I believed that the following four rules* [Discourse of Method] *would be sufficient, provided I made a firm and constant resolution not even once to fail to observe them:*
>
> ***The first*** *was never to accept anything as true that I did not know evidently to be so; that is, carefully to avoid precipitous judgment and prejudice; and to include nothing more in my judgments than what presented itself to my mind with that I would have no occasion to put it in doubt*.
> (assumption: clarity and distinctness => true)
>
> ***The second****, to divide each of the difficulties I was examining into as many parts as possible and as is required to solve them best.*
> (assumption: there are not dependences between parts)
>
> ***The third****, to conduce my thoughts in an orderly fashion, commencing with the simplest and easiest to know objects, to rise gradually, as by degrees, to the knowledge of the most composite things, and even sup-posing an order among those things that do not naturally precede one another.*
> (assumption: the sum of parts is equal to the whole)
>
> ***And last****, everywhere to make enumerations so complete and reviews so general that I would be sure of having omitted nothing.*
> (assumption: I have not made any mistake)
>
> *Those long chains of reasoning, each of them simple and easy, that geometricians commonly use to attain their most difficult demonstrations, have given me an occasion for imagining that all the things that can fall within human knowledge fallow one another in the same way and that, provided only that one abstain from accepting anything as true that is not true, and that one always maintains the order to be fallowed in deducing the one from the other, there is nothing so far distant that one cannot finally reach nor so hidden that one cannot discover*.'

Descartes proposes his method with humility, but Bacon does so with pride. He confirms its 'Faith' in The Method by writing:

> *'The lame in the path outstrip the swift who wander from it, and it is clear the very skill and swiftness of him who runs not in the right direction must increase his aberration.'*
>
> '*Our method of discovering the sciences is such as to leave little to the acuteness and strength of wit, and indeed rather to level wit and intellect.'*
>
> [Novum Organum. Aphorism 61.]

Said like this and said by an authority, it seems like an incontestable, absolute Truth (like the Truth of Faith).

Wow!

The Method do unnecessary the human intelligence, the expertise, …

Pride, pure pride! A deadly sin.

Arrogance of the Method

The Method, as a concept, was a great advance because it democratized access to the Truth, which could only be accessed by a privileged few. The Method, however, allowed anyone to reach the Truth, no matter how hidden and distant it might be. From then until almost today, **The Method has been the path to the Truth**.

*'We get brilliant results from average people managing **brilliant processes** – while our competitors get average or worse results from brilliant people managing broken processes.'*
~ Fujio Cho, Honorary Chairman of Toyota Motor Corporation. 2014.

'*Go ahead, I'm a scientist. This allows me to write this column with double moral superiority**.** First, the condition that gives me belong to one of the groups rated by Spanish society according to recent surveys. Second, the condition of knowing how to **apply the scientific method to solve problems.**'* **(**Words belong to a person, doesn't matter who, that writes a column in a main Spanish newspaper (November 2, 2011*).*

Governing by applying the Method, so that reason (supposedly) dominates over will, has been the political ideal of so-called Scientific Communism/Socialism. The adjective scientific is intended to evoke certainty, absolute and universal truth, qualities commonly associated with Science. But the model is far from being scientific because, among other reasons, no experiment to date has confirmed the hypothesis.

A common justification is to blame the failure on the application/experiment because it does not fit the method. Tom DeMarco, author of the Structured Analysis Method for software development, gives an example.

'*They (companies) were stuck on the method because it gave a comforting sense of completeness; it appeared to them to be The Answer to all of their problems. When it didn't solve their problems, they blamed themself and tried harder.'* [Tom DeMarco in 'Software Pioneers'[26]]

The above behaviour is not surprising. If the Method has been sublimated to the condition of being the path to Truth, then any failure is the fault of those who have applied the Method. Bacon's sentence is clear. There is no place for human intelligence, experience. We must apply the Method without questioning it. But what if the Method is the problem?

The case of the Communism/Scientific Socialism model is possibly the same. I believe that the failure of all applications of the model is in the premises of the model itself and not in the practice of the applications. The model assumes (premise) that humans can be molded to fit the model. The *'new man*' invoked by Che Guevara is a man domesticated to the model, an obedient robot without individual projection.

The introduction of the Method democratized access to knowledge in the 17th century, but at the cost of belittling the human because it sublimated the Method to the category of the Path to Truth. Consequence: If you do not find it, it is because you have applied the Method incorrectly. Therefore, in terms of company or State, you adapt to the Method, or I adapt to you.

The uncertainty problem

The Method has, in addition to arrogance, another problem: it requires certainties. The effectiveness of the method deteriorates with the lack of certainty, that is, in the presence of uncertainty. The recipe to make fried eggs has problems if there is no oil or fat and the problems are aggravated if instead of eggs what we have are beans.

The 17th century assumed a deterministic world; everything could be known no matter how hidden and remote it was (Descartes' explicit premise). Therefore, the Method could avoid uncertainty. But this was just an assumption, the uncertainty was there, and it could not be eliminated.

Methods become useless when there is uncertainty, more useless the greater the uncertainty. Only intelligence can face uncertainty.

> Nevertheless, the early **Software** Engineering (1970) adopted the cartesian deductive method (evidence, analysis, synthesis, reviews) as The Method to develop software and called it: the Waterfall (requirements, analysis, design, test). This Method is alive nowadays in many minds, despite having four centuries! That Software Engineering assumed a deterministic worldview.
>
> The recent (two decades old) Agile approach implicitly assumes that uncertainty is essential, not eliminable. It rejects the worldview of Modern Western Science (17th - 19th centuries) and adopt a current position. Therefore, accept and work with uncertainty. However, the Agile approach that disdains methods in the end are also methods, for example Scrum! Adhering to a recipe is easier than thinking. But this only works if the conditions of the recipe are met.

The Scientific Method

The Scientific Method, from the 17th century and inherited several centuries later, was supposed to be the rules for discovering truths, no matter how hidden and far away they may be. The Scientific Method was and still is confused, like the Way to Truth in a supposedly deterministic World. The Scientific Method was born being arrogant and despising uncertainty.

The Scientific Method was a great advance, until its initial arrogance and disdain for uncertainty reduced its credibility. It went from being the rules for discovery to being a discovery reliability protocol. Merriam-Webster currently places it in this condition.

The possibly most widespread image of the Scientific Method is a recipe/algorithm formed by a succession of steps that ultimately lead to obtaining a theory. It is a different method than the Cartesian but with the same assumptions. The steps were as followed:

- observation,
- hypothesis,
- experiment,
- and **theory** (a postulate with aspiration to be universal and capable of predict. In some sense an approximation to **God**).

This Method became **The Scientific Method** by tacit agreement of the scientific community. in principle, this Method was a path, a recipe, and steps to discover the Truth, as Descartes and Bacon thought. But a single method of discovering the world is very ambitious and simplistic at the same time.

Weinberg expresses. '*Descartes and Bacon were only two of the philosophers that over centuries they tried to formulate **rules for scientific research, something that never work**. We learn to practice science from the experience of work with it, motivated by the satisfaction we get when **our methods** get explain something*.' In short, there are no rules for scientific research, everyone does it in their own way.

There are even those who oppose the Method. 'Against the Method' which expresses '**Invention of theories** depend on our talent and other circumstances, such as **a satisfactory sexual life.**' [Feyerabend, referred to in the bibliography [3]].

Feyerabend expression is not a joke. The Scientific Method assumes that at the end of the steps (observation, hypothesis, experiments) we will inexorably arrive at The Theory, the only one (unique, absolute, and immobile) that satisfies the preceding sequence of steps as if it were an arithmetic operation.

The assumption that The Method is The Way excludes possible alternative truths about the same sequence. This assumption ignores that in each step and in the transition between them, infinitely diverse human interpretation is present. The assumption of The Method fails, among other causes, because it underestimates the human factor. Arrogance fails.

'**The method always applies to an idea**; **there is not method for to hunt ideas**. **Scientific rigor is for the treatment of ideas, not for achieve ideas**.' [Wagensberg].

In short, it seems that the scientific method, today, makes no sense as rules for research, Human intelligence, creativity, and imagination prevail. But it can be taken as a protocol to evaluate the trustworthy of the research result.

So, the **Scientific Method** (rigor**) is the standard** that the scientific community establishes **to accept a result as trustworthy.**

The book 'What is this thing called Science' [1], the text of the Seminar, is dedicated to discussing trustworthy criteria (for some the truth) according to the great diversity of scientific points of view.

Technological results also require trustworthiness, but are judged differently (e.g., Chaplin's eating machine) because it evaluates an artifact, while the Scientific Method applies to knowledge.

This difference is important in our technological/academic context to distinguish when it is about the creation of an artifact, for example an algorithm, and when it is about research around the technology, for example, what effect does this artifact produce? In the first example, the effectiveness, efficiency, accessibility, cost, market, etc., is judged, while in the second example, the trustworthiness of the knowledge that it provides about that effect of the technology must be judged. This concerns the Scientific Method. The posts for both examples will be different.

The Scientific Method seen in terms of properties

The Scientific Method formulated in terms of steps suggests a recipe/algorithm to reach the result but says nothing about the quality of the result. It assumes that the steps ensure the quality of the result. But it has already been seen that it is a simplistic assumption, that there are no universal rules for research and that the role of the Scientific Method is to judge the research. Therefore, the Scientific Method must provide evaluation criteria.

The following Scientific Method approach is an alternative.

The **scientific method** is any method that fulfils three principles: **objectivity, intelligibility, and dialectic.**

In essence, it deviates from the recipe for research (do this and that), which guarantees little or nothing, and asks that the research have properties that make it trustworthy in the opinion of the scientific community. Of course, the scientific community tuned in to this approach.

I like this approach to the Scientific Method for several reasons. It highlights what is important: the properties that give reliability to the research and free it from the straitjacket that forces it to follow the recipe. This allows, for example, to avoid experimentation as an obligatory step, and to extend the horizon of science to areas where experimentation does not make sense, nor the generalization (theories), for example in case studies. Experimentation in mathematics also does not make sense and is declared science.

Wagensberg approach establishes the properties that research must have to be considered scientific and provides criteria for judging those properties. The tolerance of these criteria further broadens the vision of science, which after four centuries, was already narrow.

Wagensberg approach is just one approach. You can argue and disagree.

Returning to the properties of the Scientific Method, according to Wagensberg.

It is **objective** when, of various forms of observing an object, the observer chooses the form that the least affects observation. *Objectivity is limited to minimize possible disturbance of the observed object.*

It is **understandable** when the representation is, in some sense, more compact than represented object.

> *'In science, understand is classifying, reduce and compress. Compression is comprehension. If there are things that you cannot compress, then you cannot understand it. Understand a natural law meaning compress this law into other law more fundamental.*
> *Are all laws of nature and suppose that we do not rest while there are two laws to understand, that is, until a law remains recessed within another. If we succeed in that glorious effort, we reach a final theory necessarily incomprehensible.' God?*
> [Wagensberg [22]]
>
> Weinberg [4] (referred in bibliography) believes in the final theory; his Nobel Prize was about Unification of Laws. Also, Tomas de Aquino believed in the final reduction, but I guess from a different point of view. However, Weinberg is restricted compared to

> Aquino. After reaching the final reduction, Weinberg cannot go further, while Aquino has another answer: God.
>
> Doing science is proposing reductions to nature. Another thing is that nature allows it.
>
> The purpose of science is understanding the world (Weinberg).

It is **dialectic** when knowledge runs the risk being shot down by the experience.

*Note, the **objectivity** restriction is related with reliability, **intelligibility** is related with purpose and **dialectic** is related with the epistemological perspective of science.*

The **knowledge is scientific when that knowledge is willing to be scientific**; that is, when it achieves maximum objectivity, intelligibility and dialectic by meagre that are such highs. Accordingly, a psychologist does not have to be less scientific than physicist ... (unless waived be). [Wagensberg [22]]

Publication as scientific recognition

Said like this, it seems that the scientific community is unique, absolute, and immobile as is supposedly the Truth it represents. But not. There are many scientific communities, they are not absolute (although some claim to be) and they move their ideas.

Scientific communities are different in nuances and even in their roots. Therefore, they also differ in the standards for accepting a result as reliable, that is, they differ in their approaches to the Scientific Method.

In fact, in practice, **each scientific journal is an individual scientific community** with its own interests and worldview, which shape its standard of acceptance (Scientific Method). Mastering these rules is essential to publish (introduce) our results. And **the publishing is the current metric to recognize scientific work**. Debatable or not, it is so.

The editors and reviewers of scientific journals form small scientific committees that decide to accept or reject the publication considering various elements. First, the editorial lines; second, their interests and finally, the severity of the research and the reliability of the result. The scientific method, as a rigorous judgment of ideas, is one more part of this process. Therefore, it could be said that work (contribution) is scientific if it is published in a scientific journal. But it could not be said that it is not scientific, an unpublished work because there are factors outside of science that affect publications.

The recognition of scientific work through its publication has been around for many years and seems appropriate because it disseminates the result and subjects it to the judgment of all readers (scientific community).

But, already in 1898, Ramón y Cajal [23] wrote. *'Numerous doctoral theses, and not a few articles in our professional journals, seem to be made not with the aim of shedding light on a matter, but rather to show off one's talkativeness and come out anyway.'*

Summarizing. The Method appeared in the 17th century as a way for anyone to access knowledge. The conception of the Method was an advance in the democratization of knowledge, but it had a negative effect: it belittled human intelligence by declaring that The Method is the Way to the Truth. The arrogance of the Method has spread to many spheres,

including politics. The scientific method is NOT a sequence of steps or iterations. In the scientific community, the Scientific Method is a protocol for deciding whether a result is accepted as scientific, that is, when an investigation is trustworthy. I prefer the following approach to the scientific method. The **scientific method** is any method that maximizes three principles: objectivity, intelligibility, and dialectic, even if these maximums are very meagre.

Reflection Seven. The Scientific Truths

In accordance with what has been analyzed so far, a scientific truth is one that is accepted through a protocol (Scientific Method), so that it is a truth by agreement. In short:

> ***Scientific Truths: Truths by agreement (through of a protocol called Scientific Method).***

Pointing out: In practice, a scientific truth is knowledge considered trustworthy by a scientific community. It is considered trustworthy when it satisfies the criteria of the explicitly or implicitly agreed upon protocol.

These criteria are influenced by the community's position regarding knowledge (epistemology), the individual perspectives and interests of the community components. What is acceptable to some is not acceptable to others. A concrete and recent example is the vaccination against the Covid epidemic. The opinion of the majority is not necessarily the Truth. It is advisable to know the protocol of our community so that the truth we propose is accepted.

These are some examples of epistemological position according to the primacy of the individual and the primacy of the object:

> **Naïve realism:** reality exists independent of human constructions and can be known directly.
>
> **Scientific realism:** it is possible for knowledge to approximate closely an external reality.
>
> **Critical realism:** our knowledge of reality is mediated by our perceptions and beliefs.
>
> **Objective idealism:** the is world of collectively shared understandings.
>
> **Subjective idealism:** there is no shared reality that is independent of multiple alternative human constructions.

Bypassing formalisms, I like this idea (NASA for children) about science because it is wide.

"Science consists of observing the world by watching, listening, observing, and recording. Science is curiosity in thoughtful action about the world and how it behaves."

Also, I like the Wagensberg approach*. 'Science: a practice that allows us to learn reliable things about the world.'*

Science, Art, and Faith are attitudes often intermingled although their truths have different qualities. '**The truth in science** necessarily changes; **the truth in art**, although not necessarily,

change; **the truth revealed**, necessarily, not change.' [Wagensberg [22]]. The respective objectives of these truths are also different but are often mixed and confused.

The Epilogue of the book *What is this thing called Science?* [1] states the author's conclusion on the topic and the title of the book. I agree with his conclusion.

'I reaffirm that there is no general account of science and scientific method to be had that applies to all sciences at all historical in their development stages. […] there is a sense in which the question that form the title of this book is misguided.'

Dreams apart, if we want to earn our bread with science, we must consider seriously the protocol and worldview of the scientific community where we are. Scientific Truth is sensitive to these conditions. Technology also is sensitive to its context. The context of chopsticks creates different conditions for technology than the context of knife and fork.

Summarizing. Scientific truth is an elusive concept because it depends on agreements influenced by general and individual points of view, including interests outside of science. However, Science has been decisive in the development of humanity. I like this idea: *Science is curiosity in thoughtful action about the world and how it behaves."*

Reflection Eight. Determinism

Determinism is a doctrine according to all that exist obeys a set of unalterable rules that act in the universe since the beginning of universe. The dream's science was, reduce the reality of the world to the predictable of a simple pendulum. But 'if the nature was governed for insensitive laws to the initial conditions, if the change was always a homothetic of the other change, never have written the "Ninth" of Beethoven.' [Weinberg [4]]

Determinism is an assumption about the behavior of the world and even an attitude. It is an assumption common to many ancient cultures such as the Greeks, part of the support of Western culture. The founders of Modern Science maintained that assumption. However, there have always been dissidents from the predominant ideas. Xenophanes (ancient Greek) said: '*The Truth sure do not know nobody and nobody will know. ... Everything is conjecture mixed. Actually, we do not know anything with certainty*.'

This was the **beauty** (a recurring concept in science) of the mechanical model of the world that according to Modern Science.

'.. implied the notion of a whole which was completely equal to the sum of its parts; which could be run in reverse; and which would behave in exactly identical fashion no matter how often these parts were disassembled and put together again, and irrespective of the sequence in which the disassembling or reassembling would take place. It implied consequently that the parts were never significantly modified by each other, nor by their own past, and that each part once placed in its appropriate position with its appropriate momentum, would stay exactly there and continue to fulfill its completely and uniquely determined function.' []

Behind: The Perfect World reflect the God Perfection.

The Science intended to discover the parts and mechanism of this big machine (created by God or by itself, according to atheist assumption). Its contribution to humanity has been wonderful!

Laplace (1776) said that he did not need the God hypothesis. If he knew the speed and position of all the particles in the universe in an instant, he could predict the past and future of the universe. It was enough to have the information necessary to determine the past and future. Laplace did not eliminate God, he just said that he could supplant him if he had God's information. An atheist but equally deterministic view of the world.

Determinism has been a manifestation of culture that is also reflected in politics. The Marxist statement of the inevitability of communism is also a deterministic assumption, befitting the timing of its formulation. But, already in the 20th century, the inevitability of communism was rejected by Gramsci, a communist leader and theorist.

Summarizing. Determinism is a doctrine according to all that exist obeys a set of unalterable rules that act in the universe since the beginning of universe. The deterministic image (with God or without It) of the world is contrary to free will and contrary to liberty in any sense. Creativity is not possible if all is determined.

Reflection Nine. Science from End to XIX Century and after

But, at the end of XIX Century the Worldview became small. Phenomena and points of view began to be perceived that did not fit into that simple vision of the world. For example.

- Given a position it is not always possible to know or return to the starting position. Irreversibility. e.g., in thermodynamic. Boltzman.

- It is not always possible to separate into parts. The Whole is different from the sum of the parts. Holistic. e.g., in dialectics. Hegel.

- Given a starting position not always is possible to know the future position. Unpredictability e.g., in the life evolution. Darwin.

In them a common element: **uncertainty as an essential part of the world**, a present element that cannot be eliminated as Modern Western Science assumed. Xenophanes' ideas began to spread much later. They have had to wait a long time for the paradigm shift.

A drastic change in the worldview began: from determinism (I can know everything) to non-determinism (I cannot know everything). A change that Hegel would call 'qualitative change' and that Kuhn would call 'paradigm change'. In any case, a leap, a break in continuity.

And the more time passed, the less simple, look at the world became. Heisenberg, Bohr, Planck, Einstein, De Broglie, … The assumptions of Modern Western Science (17th Century) lost validity.

Empirical illustration on the Uncertainty Heisenberg Principle, duality wave-particle, and diffraction (in classroom or in https://www.youtube.com/watch?v=a8FTr2qMutA

In this phenomenon (diffraction) by narrowing the slit the initial sharp image becomes a spot. When trying to specify the position of the beam of light, an opposite effect is produced that increases the imprecision. It shows that uncertainty cannot be eradicated. So, now it must be assumed that uncertainty is an essential part of the world and not a mere eliminable accident as Descartes assumed in XVII Century.

The width of the slit (subject) modifies the behavior of the light beam (object). Therefore, we must assume the presence of the observer-observed interaction which differs from the assumption of separating them as independent parts. Nor is the supposition of the division of emotion and reason valid, as has been demonstrated in *"Descartes' Error. Emotion, Reason, and the Human Brain" Antonio Damasio*. In other words, there is no emotion-free reasoning.

The uncertainty is in the observer-observed interaction. If the observer (anyone) modifies what is observed (anyone) there will always be uncertainty about what is observed.

In **software** engineering context the following occurs.

> Each software solution to a given problem modifies that problem by creating a new problem that requires a new solution.
>
> The Agile approach reflects recognition of this interaction and of the ineradicable uncertainty in software development. The Waterfall model for software development assumes that all uncertainty is eradicated in the Requirements phase in accordance with the Cartesian worldview. But neither of the two models makes their starting assumption explicit. Both claims to be based on experience. Which one do I believe?
>
> The absence of a theoretical support in software engineering submits it to the lurches of empiricism, with no other explanation than "good practices" (for some and not for others), without a reason. Personally, from my atheism and iconoclasm, I am reluctant to believe in gurus and their good practice arguments, that work today and not tomorrow.
>
> They don't say it, or they don't see it, but behind these relevant changes in Software Engineering is the paradigm shift from the assumptions of Modern Science (XVII Century) to the current assumptions of Contemporary Science (XX Century and after).

Division as a simplification tool is only valid in additive systems, that is, systems where the sum of the parts is equal to the whole, because the parts are not related.

If the parts are related, as in software systems, the division into parts causes uncertainty because the sum of these parts is different from the whole. The parts and their relationships must be addressed simultaneously, i.e., holistic way.

Finally, **the Science has been extended to the cases**.

Science has aspired to general truths, leaving aside particular truths, those that concern a specific case, and those that cannot be proven with experiments. Consequently, all the knowledge acquired from the study of those cases, of those situations that cannot be proven with experiments, has been relegated to "I don't know what classification". I could say that it has been an exclusive science.

I prefer a broader concept of science that includes that knowledge about concrete cases and non-experimental situations if they are **trustworthiness**: inclusive science. The approaches are opened but the scientific attitude is maintained, the rigor of the investigation.

It occurs to me that the idea of inclusive science coincides with the idea of science that NASA offers for children, considering that world also includes part of world (a case). Which I repeat here.

"Science consists of observing the world by watching, listening, observing, and recording. Science is curiosity in thoughtful action about the world and how it behaves."

Returning to the **software**, our home.

> Software Engineering is a good example. It was born with a deductive (Cartesian) vision far from the experimental, following the Waterfall model of software development. Software Engineering lacks general laws like Newton's laws. Its development has been based on various "schools of good practice", specific successful cases, of some that have been adopted and adjusted by others, with good, regular, and bad results. Each company, each group develops software in its own way.
>
> However, none of these characteristics diminishes the importance and impact of Software Engineering. It is knowledge relevant that in my opinion classifies as science in an inclusive sense. The evaluation criteria of its research have been and are trustworthiness related.

Summarizing. Uncertainty as an essential part of the world. Uncertainty cannot be eradicated. Division as a simplification tool is only valid in additive systems. On the contrary, the parts and their relationships must be addressed simultaneously, i.e., holistic way. There is no emotion-free reasoning.

Reflection Ten. Approximation to the Trustworthiness

By way of completion.

When I started in science, studying helictites in caves, I had a clear definition of science. But now, sixty years later, I believe that science is an attitude, a feeling. I cannot give a sure definition of science. Neither is the scientific world, as you have seen in the first part of this Seminar.

Associating science with truth is neither accurate nor safe. What do I expect of scientific findings, mine, and the others? Trustworthiness.

I think Art does not need trustworthiness and Faith is trustworthiness, by itself. But science needs to be trustworthy, it needs to demonstrate this condition in each result.

According to Cambridge dictionary

Trustworthiness is:

{the quality or fact of being trustworthy (= able to be trusted):

- *Many people said honesty and trustworthiness were the qualities that most influenced how they voted.*
- *Those actions have led you to doubt his trustworthiness and integrity.*

- *Lawyers questioned the trustworthiness of witnesses who were unwilling to show up in court.*
- *The trustworthiness of electronic voting systems has become an increasing concern.*
- *Scientists must follow their own judgment as to the trustworthiness of anything they download.*

[https://dictionary.cambridge.org/dictionary/english/trustworthiness; 2022. Nov. 10th]}

The above examples allow us to feel what is trustworthiness. I prefer to say to feel to understand because trust is something we feel, not understand. In particular, the last example says that the trustworthiness criterion for scientists is their own judgement. I agree.

Beyond the scientific method (whatever is used) as a criterion, there is a key question.

How can you and I trust my results?

The order is important (you first and me later) because by trying to convince others I have consolidated trust in myself.

Just, following this order, I will begin with another question **How I trust in your result?** [17] Unintentionally, without being aware, the first impression is produced, and we all know the weight that first impression has. Is there tune?

There are many factors that influence attunement, but one of the most important is preconceived ideas. Coincidence is frequently indispensable for attunement. However, those ideas are behind the scenes because we have acquired or built them without realizing it and we have forgotten their presence, but they are always present. And they surface immediately, but tacitly, when we are faced with a fact, in this case a research result from another. So, we tune in or not on the first impression. Later, we will see other factors.

The axioms (assumptions) of the scientific (epistemological) context are crucial in the set of preconceived ideas. Each worldview (epistemological position) has its own axioms (assumptions) on which it builds its scientific perspective, its science, in the same way that Geometry depends on the starting axioms. Unfortunately, these axioms are taken for granted and become invisible. So, we imagine that result as an undoubted truth, when in fact it depends on unspoken assumptions.

To concretely illustrate the issue of axioms I have copied a table showing the axioms of two relevant worldviews. There are others. Everyone is free to assume any of them or build their own.

Contrasting Positivist and Naturalist Axioms
[*Y.S. Lincoln, E.G. Guba. Naturalistic Inquiry. [17]*]

Axioms About	*Positivist Paradigm*	*Naturalist Paradigm*
The nature of reality	*Reality is single, tangible, and fragmentable.*	*Realities are multiple, constructed, and holistic.*
The relationship of knower to the know	*The knower and know are independent, a dualism.*	*Knower and know are interactive, inseparable.*
The possibility of generalization	*Time-and context-free generalizations are possible.*	*Only time-and context-bounded working hypotheses are possible.*
The possibility of causal linkages	*There are real causes, temporally precedent to or simultaneous with their effects.*	*All entities are in a state of mutual simultaneous shaping, so that it is impossible to distinguish causes from effects.*
The roles of values	*Inquiry is value-free.*	*Inquiry is value-bound.*

I insist, these are only assumptions on which each school builds its own scientific building. Be careful! In general, they are not compatible. In the specific case of these two paradigms, the conflict between them can be appreciated. The Positivist Paradigm see a world simpler than Naturalist Paradigm.

What arguments can be mounted, what criteria invoke, what question asked, that would be persuasive on the issue? Depends on the worldview (epistemological position) of each school of thought, ideology, … person. However, very often this very strong dependency is ignored, and we believe in the solidity of the roof (findings) while ignoring the fragility of the foundations (axioms).

Once the tuning phase or not, with the axioms and the rest of the preconceived ideas, is over, we look at what gives value to the result. The values are not universal either, each school has its own rules [see Lincoln & Guba [17]]. But they are generally associated with the following questions regarding the result.

- **Is it credible in the research environment?** For example, if it is a study of a group of people, do these people agree with the result? Has the result been compared with other similar studies?

- **Is it transferable to other similar situations and conditions?** Is there enough information for another case to find matches with ours? In Medicine it is frequent that cases are diagnosed by similarity with similar cases, without being able to speak of generalization. Medicine currently tends to personalization, to casuistry, just in the opposite direction to generalization. **Software** engineering, software development, is another field of cases, not generalizations. Each company, each group develops software in its own way, taking what benefits them from other similar ones.

- **Is the result stable, consistent?** Is it repeatable in any sense? Although, it should be remembered that "a river does not pass through the same place twice". Is there enough information to follow up, audit the investigation? For example, in a case study, can the steps that led to the results be followed in a way that can be agreed or disagreed with?

- **Is the data confirmable?** Has the observation been biased? Did you want to prove something? How much has the observation affected the observed?

Returning to the main theme. From my perspective, the trustworthiness condition is more on the side of feeling than reason. However, in science the different scientific communities demand that it be formalized. Of course, each one has its rules of acceptance according to their respective worldviews (epistemological positions), interests, ideologies, ... They are even controversial rules (criteria) within the same community. In short, there is no definitive and universal guide to acceptance.

Summarizing. It is convenient to know in depth what are the trustworthiness rules of the community (specific audience) where we want our results to be accepted. Although, really, it is an idea that goes beyond the scientific context.

End, for now.

MUSS bibliography proposal *(short commented)*

A very small proposal of books (from my library) around science, in a broad sense, for those who are interested in that World. All of them provide important ideas to reflect on.

[1] What is this thing called Science?
Alan F. Chalmer
Also, in Spanish
(The Seminar's main text. But not the only one. Especially important is the Epilogue)

[2] Discourse of Method
René Descartes
Also, in Spanish
(A foundational book, especially for early Software Engineering. Important their premises, Introduction's chapter, and precepts of his method. The same precepts of Waterfall development method)

[3] Against the Method: Outline of an Anarchistic Theory of Knowledge
Paul Feyerabend
Also, in Spanish
(A key rebel book Against Method. It is interesting the critical analysis about Galileo's discourse to demonstrate his theories.)

[4] To Explain the World
Steven Weinberg
Also, in Spanish
(Very interesting book written by a Nobel Prize of Physics. It is the vision of a scientist)

[5] The Care and Feeding of Ideas
Norbert Wiener
Also, in Spanish as "**Inventar**"
(An excellent analysis about the process of Invention)

[6] Descartes' Error. Emotion, Reason, and the Human Brain
Antonio Damasio
Also, in Spanish

(Indivisible relation between emotion and reason)

[7] Einstein's Space and Van Gogh's Sky
L. LeShan and H. Margenau
Also, in Spanish
(A physicist and psychologist write about what is reality. For example, is God real? I think yes, although I am an atheist)

[8] How Real Is Real?
Paul Watzlawick
Also, in Spanish
(Reality is the result of communication, it is not the reflection of eternal and objective truths)

[9] Does God Play Dice?
Ian Stewart
Also, in Spanish
(The collapse of predictability and indeed: the collapse of determinism. Laplace, Descartes, … were wrong)

[10] The Pleasure of Finding Things Out
Richard Feynman
Also, in Spanish
(Confessions of a Noble Prize about his work doing Science. I love his texts for teaching Physics. Although Feynman gives a key role to experimentation in science, his scientific thought has a broader horizon)

[11] Six Easy Pieces
Richard Feynman
Also, in Spanish
(Essentials of Physics Explained by a Brilliant Teacher. They are six chapters of his textbook on physics)

[12] God and the new physics
Paul Davies
Also, in Spanish
(Analysis of the science-faith debate from the perspective of quantum physics)

[13] Trends in General System Theory
L. von Bertalanffy and other
Also, in Spanish
(Set of foundational essays on this worldview born in the 20th century. From my point of view, the General System Theory is the better approximation to support Software Engineering, for now)

[14] Introduction a la pensée complexe
Edgar Morín
Also, in Spanish
(Set of essays about what is the concept: the complex)

[15] The Taming of Change
Ian Hacking

Also, Spanish
(A look at the evolution of statistics and its influence in almost all, including judges It is interesting to know what is Normal)

[16] Man's Search for Meaning
Viktor Frankl
Also, in Spanish
(From my point of view, this is a painful qualitative Case Study about human behavior in the Nazi Death Camp. In addition to the results, it is convenient to study his scientific method of work, no experiments or numbers. His results bring concrete knowledge)

[17] Naturalistic Inquiry
Yvonna Lincoln and Egon Guba
Only in English, that I know.
(This book is important for understand the qualitative approach to research. It discusses the fundamentals of that approach comparing with classical approach)

[18] Qualitative Data Analysis: An Expanded Sourcebook
M. B, Miles, and A. M. Huberman
(A book about Qualitative Research)

[19] The Fear of Freedom
Erich Fromm
Also, in Spanish
(Because Science is a product social and cultural, it is very important to know how those factors influence in our freedom of thinking and to do science)

[20] The Left Hand of The Electron
Isaac Asimov
Also, in Spanish
(Funny essays about science. Specially chapter 12: Certainty of Uncertainty)

[21] Only an Illusion
Ilya Prigogine
Also, in Spanish
(This book is the vision of Physics of this Noble Prize. His vision moves away from the determinism approach of science. Metaphorically, Prigogine expels Adam and Eve from Paradise, and he placed it in a complex world where the linearity and predictability are scarce)

[22] Ideas para la imaginación impura
Jorge Wagensberg
Only in Spanish, that I know.
(A delicious book about science with suggestive and relaxing ideas. Specially I like his concept about what is a Scientific Method and the coordinates of Science, Art, and Religion in the knowledge space)

[23] Reglas y consejos sobre investigación científica
Santiago Ramón y Cajal
Only in Spanish, that I know. But affordable web
(Very important book for beginners from this Nobel Prize. I recommend it. What he has written, I have experienced many times)

[24] De Tales a Newton
Juan Meléndez
Only in Spanish, that I know.
(An interesting book about the evolution of scientific thought)

[25] Perdidos en las matemáticas. Cómo la belleza confunde a los físicos
Sabine Hossenfelder.
(In English, 'Lost in math')
(A critical analysis of the influence of beauty in science)

[26] Software Pioneers
Manfred Broy, Ernst Denert (Eds.)
(A set of papers have been relevant to Contribution to Software Engineering)