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Knowledge as a Tale

A Discursive Space

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To my children: Suzy, Stan, and Joan.

Introduction

Knowledge is a concept which involves a great effort to explain its meaning. A work that illustrates this effort really well is Mark Burgin's *Theory of Knowledge. Structures and Processes*, which the author of this book considers an illustrious example of both humility and panache. This effort translates into an extensive library of publications addressing the matter of knowledge. In this book, I do not intend to summarize them. Rather, I follow my own narrow path through the dense forest that these works form, to refer to Umberto Eco's excellent and simple metaphor, leading to a predetermined goal—the aforementioned idea of discursive space. I have arranged the chapter titles using a number of select figures acting as their good guardians and as guides at the same time. However, they quickly get lost in the mazes of the corridors they have discovered, which become populated by other characters and run further towards the future. It needs to be added here that in order to cover the expected distance, which I am about to describe, one has to run many special sections dealing with certain specific issues. My hope is that they will not only form some kind of a consistent whole, but also provide a solid dose of knowledge about each other, offered in a concise and accessible form.

The story starts early and runs along a peculiar path at the beginning. This path is called a "digital transformation". This is the name of a seemingly uncomplicated phenomenon, which in fact hides little-known, very important, and still active sources of knowledge, to which the first part of the book is devoted. On the one hand, it defines the fashionable process of evolution of the economy and society in that order, which is the result of the mature implementation of the opportunities and techniques created by digital technologies. Mature, i.e. one in which these technologies create successive levels of applications, creating new phenomena and new areas of their use, such as the Internet of Things (IoT), big data, or artificial intelligence. It should be remembered that these terms are ambiguous, but are most commonly understood as certain economic products. They are also the source of great transformations not only in the economy but also in social life.

On the other hand, a literal analysis of the concept of digital transformation reveals events in the relatively recent past that dramatically affect the process of understanding the nature of the world and the ways in which this process takes place. Its origins are lost in the deep past, but it becomes especially intense in the nineteenth century, especially towards its end, and carries over with the same intensity to the beginning of the twentieth century. It is a story about mathematics and geometry, and about its basic being, which is the number, whose good and uncontroversial description we do not have until today. Mathematics becomes a model for analyzing the world and, at the same time, for its description, which accompanies more and more insightful, subtle and sophisticated ways of doing it, which make it difficult, inconclusive, and ambiguous. There is no paradox in this, but the usual process of digging deeper and deeper into the problem, which does not lead to solutions, but multiplies questions.

However, a very clear cognitive paradigm emerges from this confusion, which is surprising and contrary to common sense, but extremely fruitful. It is based on the idea of an axiomatic system, i.e. a certain innovative and revolutionary descriptive structure that changed the methods of mathematical or geometric description. It allows one to build a description system whose only structural principle of correctness is internal consistency. This means that the principle of representing the world, i.e. confirming this correctness by empirical means, is rejected. In fact, the process of describing is reversed: First a theoretical system of description is created, which can then be applied empirically. This method, inconsistent with common sense and previous practice, whose modern father was Galilee, turns out to be extremely effective. Above all, however, it changes the approach to the nature of cognition, making the theoretical abstract more important and the first step on its way. Inevitably, theoretical abstractions are becoming more and more bold and lead to such unusual proposals of cognitive constructions as a system, network, or complexity.

What is more, a new way of understanding the mutual positioning of theoretical reality based on conceptual abstraction in relation to the reality of practical experiential beings appeared. A new version of the encounter between the world and the subject emerged, clearly and distinctly formulated by Descartes. The new idea abandoned the claim of truth or uniqueness formulated by Plato. Instead of one truth, numerous contextualized interpretations appeared. The twentieth century was a picture of the explosion of various variants of these contexts, which took on a predominantly social character. Thus, a story of knowledge that is not philosophical speculation but is based on the observation of historical and social events. It is a story about knowledge that determines social processes, defining the practice of life and constantly changing. Its nature and the chosen way of description cause this story is the result of choice and interpretation, which is usual for the story as such, as Umberto Eco described. This is also the nature of the second part.

Thus, in the chapter beginning part II, number 3, I describe the key place where the problem of the world's inaccessibility to direct insight is revealed with all its force: language. At the same time, the story of knowledge in this part takes its basic shape, in which important single characters become the axes of its individual stages. Although similar anxieties about language had appeared earlier, it was only Ludwig Wittgenstein who conducted a thorough and dramatic analysis of it in two works that turned out to be one of the most important philosophical visions of the twentieth century: *Tractatus Logico-philosophicus* and *Philosophical Investigations*. The dramatic effect stems from the fact that they generally differ in the way in which they understand the language. The evolution of Wittgenstein's views proceeded from the logical discipline of language to a vision in which it appeared as a specific, complex, and continuous game or labyrinth. In this situation, the relationship between language and the world, which emerged at the end, also became a new epistemological model and rhymed perfectly with constructions such as network or complexity.

The next chapter of Part II, number 4, begins with a mention of Edmund Gettier's achievement, I point to a certain overexploitation of the notion of knowledge, which (rightly) seems to be too simple and, indeed, is underlain with an error that can only be remedied by moving the reflection to a somewhat more general and abstract level. This introduction, somewhat anecdotal in that it recounts a discovery, will show the rapid and latent flow of new thoughts that are about to be revealed, heralded in the field of the humanities by the like of Michel Foucault. But this will happen only in Chap. 7 because in earlier parts, playing with the dynamics of historical time, stretching or shrinking almost relativistically, but respectfully approaching the order of birth of a new worldview, I will talk about knowledge undergoing a dramatic transformation in the way it has been treated and perceived. This process will run through the area of a broader line of thought concerning man and man's self-organization in the world, and thus through the paths of sociology and its branches that describe humans' efforts aimed to enable them to comprehend the surrounding world.

It is no exaggeration to call this process the emergence or creation of a new human world, and the wave of new ideas and events that engulfs and subverts it, leading to new arrangements in the 1960s and 1970s, is very powerful—and its impact continues to this day. This is more or less what I discuss in Chaps. 5 and 6, delineating thus my own symbolic heroes: Ludwik Fleck, who prophetically reminded science of its social place, at the same time destroying the metaphysical (epistemological) hubris in which it had been wallowing. For what else could a conviction of exclusive access to truth be? A conviction similar to a religious one, only even more egotistical. Masuda acts as a symbolic exponent of this breakthrough, making mankind realize that it has finally fulfilled a prophecy well known in almost all cultures—meaning that it has have set in motion forces that they are unable to control and that will ultimately destroy them, which can mean a profound transformation of the entire civilization across all of its levels and areas. We are, of course, talking about digital technology here.

At this time, knowledge is thrown on the table, becoming the object of curious inspection and study as a potential raw material—into which it eagerly soon turns. Its old and unusual nature is uncovered by Foucault, revealing an interior that is fragile and connected to the human environment in an extremely complex way, as described in Chap. 7. This is the very body of knowledge picked up by Lyotard, who plays the symbolic role of a visionary here—he sees the great causative power of knowledge in the ethereal substance of it, already materializing but still alien. It is no longer a piece of strange matter lying motionless, but a tissue torn from its social body, acting simultaneously as its bloodstream, nervous system, and skeleton—and actually forming the entire body thereof as well. This is the conclusion to which the final—eleventh—chapter offers. But for the time being, in Chap. 8, as groundbreaking as the previous one, we celebrate the act of making use of the power source inherent in the substance of knowledge.

The next two Chapters, 9 and 10, follow a bit different pattern but still manage to retain the adopted convention. They are based on a deep belief that the metamorphosis of knowledge has already taken place before our very eyes and that it is necessary to highlight those sources of thought that will make it possible to describe it in its new form. There are two of these sources. And even though they differ in terms of their subject matter, they are similar in the way of reasoning—abstract, advanced, piercing through and fleeing the hard material surface of the world to take advantage of constructs built in other spaces—far more general and basic. They are discourse and space. They are also difficult, not obvious, and incompatible with common experience, so they require separate research because they simultaneously open up completely new possibilities for understanding and describing the world.

In the structure of this line of thought, the two chapters provide direct methodological preparation for the construct that appears in the final chapter, 11. This already mentioned chapter presents the idea of the so-called discursive space, which has been conceived as a descriptive model of knowledge that uses the phase space construct, combining qualitative and quantitative approaches. This idea has already been presented in several articles, but in this book, it is complemented by an extensive introduction and rationale not published elsewhere. The chapter in question is the culmination of the book and supports the concepts and structures described in previous chapters. The author's intention is that this final chapter should arise from the preceding ones, gathering the necessary content along the way like a river from its tributaries, in order to eventually turn a single stream, shaped by circumstances, yet running in an orderly, arranged manner. This is a risky structural assumption because such an order does not refer to the familiar composition of reasoning: assumption—hypothesis—proof. Thus, it does not seek to answer the question of how the world really is and validate that answer as relevant. It merely proposes a cohesive and internally non-contradictory proposition, which is, however, quite free within that cohesiveness and multiplies possibilities rather than closing them off and excluding them in the search for the right ones. It is a tribute to the unbridled nature of thought and necessarily a tribute to its opus—knowledge.

Finally, I would like to thank the important people who have provided me with the necessary and valuable inspiration: Marek Burgin, Marcin Schroeder, Wolfgang Hofkirchner, Piotr Bołtuć, and Marek Hetmański.

Kraków
11.02.2023

Introduction No 2

Now that we know what a book consists of, it is time to introduce a different type of introduction. I will try to explain the shape of the book: a digressive and multi-threaded story. Such is the case in this introduction, which is not a uniform reasoning, bound by an iron discipline of conclusions. It is a growing set of different circumstances that at some point will exceed the critical mass and become a coherent wholeness. Through this wholeness, the sun of final meaning of the notion of knowledge should finally light up.

It is not the phenomenon of knowledge itself that is recalled here, but the notion that names it. This is the basic analytical decision that determines the most general research perspective. This notion is like a footbridge that connects the busy and deceptive world of language with the world itself. Provides tools to talk about our environment, understand it, record it, and ultimately include it in our own world at all levels of its generality. The unusual features of language have been observed since antiquity, but only since the beginning of the twentieth century has it become the subject of advanced reflection, the canonical examples of which are the works of Ludwik Wittgenstein and Ferdinand de Saussure.

Language is, of course, a function of the social nature of human relationships. Everything that happens in language has its source there and ultimately shapes these relationships. This mutual and complex process can be understood as the basic and even the only way of generating all experience and at the same time shaping human societies. This is how it was perceived, among others, by Michel Foucault, a researcher who made this fact the core of his extensive philosophical reflection. His approach is the main inspiration here. Notions appear at the forefront of this process because they go to impact as the first surface of the world they try to capture and—as imperfect, momentary, and local—they are always doomed to failure. They perform their duties so poorly that they remain inaccurate, partial, and context-sensitive. They are also subject to the process of change and reconstruction.

This fact became the basis for concern about the phenomenon of knowledge and the axis of thinking about it. The reason for this mode of approach to knowledge is obvious. This book, its introduction, and all other extremely rich analyses and findings on knowledge cannot avoid the mediation of language. Talking about knowledge is always using a certain notion that refers to knowledge as a phenomenon. There is a vast literature dealing with the phenomenon of knowledge, beginning with Plato's dialogue Theaetetus, which contains its famous definition, also discussed in the book.

Language, which is an environment of notions, has roots as deep as the existence of the people and societies of which it is the fruit and companion. It is a process and an event, in which it is similar to the notions in which it consists. The notion of knowledge is, of course, of the same nature. We are talking about words, the most basic tissue of our speech. When we observe how they appear, how they operate in each act of using them, and how they change, we can naturally ask two questions. The first question arises about the process of historical change in the meaning of a notion and the relationship that connects it with its counterpart in the world. This question immediately turns into a task of examining the historical circumstances brought about by the passing years during which this change takes place.

The second question naturally concerns the current state in which the notion of knowledge appears. This task is paradoxical because it attempts to freeze the changing shape of the notion in a stable image. However, the reasoning presented in the book tries to avoid this mistake. For this purpose, it proposes a model that takes the analysis of the concept of knowledge beyond this dialectic using a descriptive structure, which is a dynamical space. This model is called discursive space and is described at the end of the book. Although the construction of dynamical space comes from the field of physics, it is also well represented in the social sciences. However, dynamical space is based on the idea of describing variable and moving processes. Therefore, it must be supplemented with a justification and description of the dynamics of the notions it deals with.

The first question and task at the same time, the one that respects the variability of the concept of knowledge, therefore remain the axis of the research work. The reasoning carried out in the book is inspired by the idea of complexity, the dynamics of which is based on incalculable, mutual interactions, going far beyond the usual cause-and-effect order. Rather, it is based on persistent tracking of these dense contexts in which the notion of knowledge is entangled, revealing itself thanks to them, in confrontation with them, in mutual dialogue. A careful reader will notice an attempt to apply also the best analytical traditions of Hans Georg Gadamer and Michel Foucault.

If we adopt this mode of reasoning, two important circumstances immediately appear, which we will discuss in turn. The first circumstance is that an extraordinary, yet obvious, transformation of the object of our investigation is taking place before our eyes. The second one concerns the rapidly expanding perspective from which we look at language and its notions, but more on that in a moment. Let us start with the mentioned transformation. It occurs because the more we entangle the problem of knowledge in the contexts in which its notion appears, the more the phenomenon of knowledge diversifies and enriches. This is the result of an extraordinary feature of language, according to which notions gain meaning only when they participate in the game of their direct use. This is one of Wittgenstein's most famous observations—the language game that creates the meaning of concepts is a whole consisting of language and the activities into which it is woven. It is obvious that the more often these notions are used and the more numerous their contexts appear, the richer and more complex their meanings become.

It seems at first that starting the search for the answer to the question of what knowledge is from a notion instead of a phenomenon is a false inversion of the usual order of experience. This order is based on a natural progression from the wealth of phenomena revealed to the observer to subsequent attempts to organize and explain them. However, here the order is reversed: it is the reconstruction of the notion, its participation in [new] activities in which it can be used, creates a new way of understanding it, which leads to organizing the observed world in a new way. Therefore, language comes first, not experience. Therefore, the first is the descriptive system, not the object of description.

This seemingly paradoxical approach, in a slightly humorous and simplified way, presents one of the most important cognitive inventions, which was the axiomatic system that appeared in the area of geometry and algebra. I devote a lot of space in the book to describe its uniqueness, which consists in opening completely new and dazzling ways of looking at the world. He abolished all limitations of imagination, which for centuries had been forced to keep thought consistent with experience. The revolution took place at the turn of the nineteenth and twentieth centuries, completely changing the approach to mathematical and geometric entities, quickly becoming an inspiration for the humanities.

The freedom to create new worlds, which was also realized in art as pure abstraction, allowed for the formulation of one's own rules for generating theorems in geometry and algebra. The only requirement was to maintain internal coherence, defined at the beginning. It is therefore not surprising that formalism, which meant the complete abandonment of the representing the world in cognitive constructions, became of great importance in the process of creating theories, both in mathematics and art. Their justification was entirely contained in the descriptive system itself, without the need to look for evidence in the world outside.

The lesson of this freedom, which also meant the need to completely reconstruct the idea of truth, was also a lesson of the existence of many parallel possibilities of understanding and describing the world. The number of possible geometries and mathematics is virtually endless. This conclusion was both creative and bitter. It also necessarily raised a fundamental systemic doubt in the descriptive systems that had been operated so far. Their claim to exclusivity, based on consistency with experience, turned out to be illegitimate. This doubt has generated new, paradigmatically deep research approaches. One of the fields in which it was realized was, of course, language, led by the vision presented by Wittgenstein.

Wittgenstein's concept should be seen as the ultimate reconciliation of both sides of the cognitive situation: language and the world. The language game consists of both of these elements, and yet there is no prior clear recipe for the nature and structure of their combination. Wittgenstein initially assumed that language was a coherent formal system that followed the rules of logic, reflecting the similar nature of reality. Later he completely denied this belief. The place of logic and coherence has been replaced by play and affinities that appear locally, so there is no point in searching for their metaphysical foundations. In such a situation, the study of meanings becomes collecting the implementation of notions, searching for momentary regularities that constitute families of concepts, variable, and blurred. This means many simultaneously existing affinities, or, in other words: systems of justifying them.

I have devoted a lot of space in the book to illustrate the description I have just given of how language works. One of the most important paths of reasoning leading to it led through the concepts of Michel Foucault and Jean François Lyotard. Both of them were convinced that there must be some structures that exist beyond notions and their systems. These structures produce meanings in various ways in parallel, replacing themselves or co-existing, and changing during the historical development. Foucault used various terms, of which the most famous and the most widely developed is discourse. Lyotard introduced another term: narrative. In each case, the aim was to identify overarching and at the same time local meaning systems that combined consistent instances of lower levels of language, such as notions or sentences, into internally coherent meaning constructions. They both also had no doubt that these systems were also coherent articulations of certain knowledges. The plural form of this notion is used deliberately to ostentatiously break away from the otherwise suggested fiction of one knowledge, true by definition.

Both discourses and narratives provide sufficient justification for certain knowledges that exist simultaneously in a numerous, practically infinite set of variants. These are descriptive systems similar, even analogous, to the formal axiomatic systems that destroyed the hegemony of Euclidean geometry and traditional algebra. Confirmation of this thesis can, for example, be found directly in Lyotard, but the similarity of the dynamics of thought struggling with the curse of the compliance with the world, thought that rebels and liberates itself, is striking. You can see it sailing towards unknown lands, boldly and without fear. All these poetic metaphors are justified because the challenge that appears before the conscious mind is great. It makes it an adversary equal to the world, although it ultimately leads to his defeat because formal systems, as Karl Gödel proved, are ultimately, in their fullness, unattainable.

Language, however, is not a formal system; it is its living negation, running through a multitude of various configurations of meanings and various logics immediately, in one act of its use. This is why poetry exists. And it leaves traces of its appearances and presence in the universal memory of its creations such as discourse. This memory is, of course, not eternal but multiplies associations and contexts. This is why Wittgenstein compared language to an old city with an ever-expanding tangle of streets, allowing one to wander to one's destination in an ever new and different way. In each such journey, new sights and encounters appear, making it an exploration of the unknown, that is, what has not been part of the journey before. New curves and straights appear. The course of the journey changes, forcing its reconstruction. The notion of knowledge is subject to such dynamics as that I discover in the book showing how different and new roles it can play.

This complex processing of meaning would not be possible without the property of language with which we began this introduction. This property was considered the second key factor in its existence and operation. So far we have focused on the internal dynamics of notions that animate it, but now we need to change the perspective and look at language as an extremely extensive event existing in the social environment. Language is created between people and remains only between them—this is obvious, and they, thanks to language, among others, establish relations of a very complex nature. Language is an event of unprecedented, massive scale. Bruno Latour understands the notion of social as a movement, a displacement, a transformation, not a real and stable situation or object. Language inherits this dynamic, which is undoubtedly complex in nature. It means that, among other features, language does not allow for tracking and accurate reconstruction of mutual dependencies expressed in simple cause-and-effect connections. There are too many of them. And they develop too many relationships. So much that by definition they escape the analytical apparatus, allowing themselves to be observed only as certain wholes heading in a certain direction. In this practical way, a working environment for notions is created.

Foucault, Lyotard, and others were perfectly aware of the described mechanism of language operation, which could be described as "social", although they did not call it complex in the sense that this concept was acquired only in the 1970s. They also had no doubt that it is a vehicle of knowledge that is revealed and shaped in all expressions of language. Researching the notion of knowledge is completely justified from this point of view, although less expected due to the role and perception of this phenomenon. It was enough to draw conclusions from the collected premises and wander with the notion of knowledge through its articulations, which turned out to be an extensive and branching journey, and then write down the experiences of this journey.

In this wandering, expectations and decisions (and therefore the order of wandering) are constantly reconciled with unexpected encounters and discoveries. It is therefore difficult to maintain complete discipline in the argument, although, of course, such effort accompanies the journey (directions, documents, maps). On the other hand, you cannot avoid the poetics of the story, which consists of adventures, surprises, and sometimes pulls the writer towards alleys, starting new, complicated threads. At the same time, the story remains an act in which the listener or reader is indispensable. Although it is intended to be monologue-like in nature, the story needs the presence of another person, and thus becomes a strong element of what is social. Finally, the story, freeing itself from the nature of proof in reasoning, on the other hand opens itself to uncertain knowledge that is difficult to gather and organize. However, it opens the possibility to speak openly and freely, even make things up, but not lie, demanding only tender acceptance of weaknesses. In this situation, it remained only to tell a story.

Contents

Part I
Digital Transformation

Chapter 1
The Digitality of Digital Transformation

The notional cluster reading ‘digital transformation’ became a popular search in Google only in 2015.[1] Before that year, its search trend line appears to be flat, adjoining the horizontal border of the chart. Of course, it is only a curve illustrating the relative level of interest compared to the maximum level, not a chart based on absolute numbers. Plus, it only covers the period from 2004 onwards. But its shape is distinctive; it climbs consistently from the said year 2015, and the maximum level comes at the very end, in 2019, so it is quite likely that the rising trend will continue. The chart shows two qualities clearly: the presence of a significant trend and the relatively close initiation of the period of an increased level of interest. The notional structure of digital transformation is therefore much younger than the technical innovations it is associated with, and has been in the broader intellectual circulation, so to speak, for only a few years now. This means that the need to address some fragment of reality using a new idea has appeared relatively recently as a cognitive action, resulting most likely from a growing impression that the old, established processes entered a completely new stage at some point—a stage calling for a new naming tool, a tool enabling the inclusion of new ideas into the existing body of knowledge. This new notion therefore tells us a lot about the ability to understand the world, and not about the world itself.

“Digital transformation” is a cluster of two words. According to the Oxford University Press dictionary (Lexico.com 2020), the first word—“*transformation*”—comes from “(to) *transform*”, which originates from the Latin verb “transformare”. The latter is a product of two words: the prefix “trans” and the root word “form”, which may function as both a noun and a verb. The original Latin word “trans” means “across”. The word “form” comes from the Latin “formare”—“(to) form”, which in turn stems from the Latin “forma”. The latter, however, does not close the spectrum of meanings but actually opens it. This spectrum of meanings starts with

[1] https://trends.google.pl/trends/explore?date=all&q=digital%20transformation (accessed on: 8/15/2019).

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a deep reflection on form as discussed by Aristotle in his “Metaphysics”, where the philosopher argues as follows: “by ‘form’ I mean the essence of each thing, and its primary substance” (Aristotle 1933).

The idea of form, as it appears, is deeply ingrained in metaphysics: it defines the essence of things, meaning their manifestation in the world, which constitutes everything they are, the roles they perform, the relationships they form, etc. This essence shapes their matter, which is the second fundamental aspect of the Aristotelean ontology next to form. Moreover, form is rooted in the primary and only cause of everything, so it does offer some transcendental sanction set beyond the boundaries of the human world. Changing an object’s form is therefore a dramatic interference with this object, an alteration of its essence, an act of placing this object among other objects and arranging all these objects in some specific order. Transformation can then be understood in this context as an act of crossing the existing essence of a given being. An act of re-forming its presence in the world and in relation to the world. If we do not pinpoint such a being, it could seem it concerns everything, all, a fundamental and limitless traverse. One needs to think very carefully if perhaps the said intuition does not underlie the word in question when this word appears in the cluster “digital transformation”.

Moreover, transformation is a certain deep-rooted and constant property of the world—which stems from its fundamental and imperfective nature. It describes something that lasts, something that is both a course and a process by its very essence. All in all then, when considered as a notion and a vision of the world at the same time, it is a paradox. In a single description of the world in the form of a word, it encompasses a certain continuity, meaning it makes this word divisible and discrete, thus interfering with its essence. The paradox is not necessarily a mistake, but rather a guideline offered to us by our system of reasoning, suggesting that we have encountered a problem the system is not able to handle and thus requires switching to a different, more general level of thinking (Sorensen 2005). In the case of transformation, the paradox is about a certain disproportion between the world and the language used to describe it and the technique utilized by the language to deal with the problem. It is clear that the said disproportion—or the inaccuracy or incompatibility of the language we use—is the main and frequent flaw of this language. A reflection on the mechanism underlying these properties of language will make it possible to determine its ability to describe the world. Our ability to describe the world. The problem in question, which concerns fundamental matters after all, will be raised in the chapter addressing the general bases and sources of reasoning.

The second word in the phrase “digital transformation”: “digital”, acts as a *differentia*, meaning that it offers a distinction which makes it possible to define some specific part of a greater, superior whole (genus)—being transformation. This order arises from the classical idea of definition, which is based on the theory proposed by Aristotle in “*Topics*” (Bayer 1998, 487). The type of relationship included therein shows that the idea of transformation is more general, ranked higher in the hierarchy of the description of the world. This is otherwise clear in light of the sense stemming from the Latin etymology of the word *“form*”. It describes, after all, certain fundamental features and qualities of the world, with other features and qualities being additional and secondary to the former. This is a very important conclusion. One that stresses the part of the phrase which is usually somewhat disregarded. Transformation as an idea and a phenomenon is obviously older, more fundamental than its digital face, so to speak.

The word "digital" offers similarly interesting and rich coincidences. It comes from the word "*digit*", originating from the Latin "*digitus*"—"finger", but Merriam-Webster adds that it might be *perhaps akin to the Greek* "*deíknȳmi*", "*deiknýnai*" (Merriam-Webster.com 2019b), and the word that means "(to) *show", "(to) point out*" comes with a broad spectrum of continuations in many languages (Merriam-Webster.com 2019a). Varanini provides an in-depth analysis of connotations related to these types of meanings, which form an interesting network of related meanings. Showing, pointing, associated with the finger, has its source in the Proto-Indo-European language, and can be found in Sanskrit as well. For Varanini, it is a sign of a fundamental significance of the act of showing, which makes it possible to differentiate the elements of the world from each other. Its presence in the context of numbers is therefore certainly not coincidental, especially since the English word "finger" has its roots in Proto-Germanic, to which it was imported from the Proto-Indo-European word "pénkwe" ("five"). Showing and counting seem to be closely related acts. The former precedes the latter in the sequence of organizing and naming the surrounding world (Varanini 2018, 15).

The word "digital", apart from its anatomical sense referring to fingers, not only points to digits per se but also focuses on those which form the binary system, meaning only two of them: 0 and 1 (Lexico.com 2022). Today, what can be defined as belonging to the digital domain, is binary by default. The binary system—but also the very principle of the establishment of such a system—is the foundation of modern computing. Two states can reflect many different values—not only digits but also the dichotomy between true and false. They can be shown as an opposition of presence and absence. Software engineers do not need their ontological interpretation, which certainly underlies the said opposition. All they need is the presence or absence of electric potential, which shapes physically this dichotomy and enables manipulating its symbolic senses: digits and logical states of true and false.

The Merriam-Webster dictionary highlights another—clearly distinct—semantic context related to the word in question. One which continues the emerging coincidence with the computer reality. The context is underlined clearly by Floyd in his textbook on digital electronics: "**An analog quantity** is one having continuous values. **A digital** QUANTITY is one having a discrete set of values" (Floyd 2014, 16). This discreteness, meaning a division into clearly separate parts forming a stream, mimicking an uninterrupted flow of a real, source phenomenon, is the technical quality on which all technical digital solutions are based—contrary to the analog ones. If we take a closer look at the case in question, the logic of quantification is an immanent trait of a number and a logical state. It can be challenged, assuming an infinite range of a number as a certain abstract and blurring the logical border between true and false. This is how the dialectics of continuum and singular states, an issue of considerable importance at a certain level of advancement of mathematics, comes into play. The world seems to be continuous, but counting in in its different aspects appears to necessitate divisions. An example is the simplest physical processes, such as the movement of the body in space. Describing these processes in mathematical terms started from Newton and Leibniz, who introduced a very basic mathematical tool: the infinitesimal calculus (Kline 1972, 342). Ancient Greeks were not familiar with the contemporary notion of continuity. This lack of knowledge was what Zeno of Elea's paradoxes were based on. Continuity has one more flaw: it disappears in infinity, which is a certain indivisible whole. This way of existence was first understood only in the nineteenth century thanks to the concept of Georg Cantor (Kline 1990, 992). And thus we are moving inevitably closer to the problem of number.

Number and Mathematics

The foreground of the word "digital" is occupied by a being called 'digit' which carries a tale of a great intellectual adventure of man. Georges Ifrah's book entitled "*Histoire universelle des chiffres*" (Ifrah 1981) is a monumental work that tells this tale with great zeal. Its author has no doubt that it is story of mankind, dating back to its very beginnings, connected with the very basic ability and need to count, present in all cultures and with its roots hardly traceable. The act of counting in the times when it emerged was based on the use of various small objects, sometimes made for this purpose, such as rocks or clay figures. Its progressing development, the growing range of its applications, and the increasing level of its complexity led with time to the invention of a symbolic representation of counting tools in the form of digits. Irfah claims that the oldest known symbolic pictograms representing digits were created by the Sumerians in Lower Mesopotamia about 3200 BC (Ifrah 2000, xx), which generally coincides with the appearance of writing in this place and at this time.

Counting, numbers, numerical systems are all a great record of the intellectual achievements of man, being a sum of inventions created in different parts of the world, whose evolution led to the emergence and development of a discipline of extraordinary importance—mathematics. Mathematics offers an unignorable context where the presence of a symbol such as a digit takes a relatively most advanced form, reflecting a certain state of understanding of the world that accompanies it: a certain knowledge, a view of convictions or beliefs. Wilder argues as follows: "mathematics is not something which is by its nature universal, absolute, or foreordained; it is subject to laws of development and influence from other cultural elements much as are arts and sciences in general" (Wilder 1967, 285). It is hard to imagine digital transformation without computers, and computers without mathematics. The dash accompanying the gradual progression in this branch of knowledge is characterized by a dynamics of its own.

The brief history of mathematics, as told by Ifrah (2001, 72), begins around the eighteenth century BC in Mesopotamia, and then shifts to ancient Egypt to emerge in Greece in the fifth century BC, where it develops thanks to Pythagoras, Archimedes, and Euclid. At the beginning of our era, the development of mathematics is joined by China followed soon after by India which contributed the notion of zero—the opposite of infinity; an idea based on mystical depth, a concept unknown in Europe at the time. In the ninth century, the process of the development of mathematics was joined by Muslims: Al-Khwārizmī (the Latinized version of his last name gave birth the word "algorithm"), Abū Kāmil, Al-Karajī, and others. In 1202, Italian mathematician Leonardo of Pisa, also known as Fibonacci, wrote his "*Liber abaci*", which documented the achievements of Arab and Greek mathematics, becoming the foundation of European mathematics for the next three centuries. The development of mathematics moves to Europe, and Western civilization gradually overshadows the rest of the world in the achievements in the discipline because—as it is easy to see—political history is reported as part of the history of mathematics with absolute precision, repeating the image of politically and civilizationally dominant parts of the globe.

The development of mathematics in Europe in the nineteenth century and at the beginning of the twentieth century brought surely the most advanced and abstract way of perceiving numbers, which is connected with the most fundamental questions regarding mathematics and its beings. The nineteenth century is also a time of revolutionary changes in mathematical ideas. The earliest geometry is subject to a dramatic transformation manifested in full bloom in the idea proposed by Hilbert in 1899 in his *Grundlagen der Geometrie* (*The Foundations of Geometry*). The idea of axioms was known since the age of Euclid, but Hilbert defined them in a clear way as a self-aware, arbitrary, own, and free selection of assumptions on which a further formal reasoning is to be based. The idea was put forward even some time earlier by Peano. In the introduction to his work, Hilbert states that his investigation "is a new attempt to choose for geometry a simple and complete set of independent axioms and to deduce from these the most important geometrical theorems" (Hilbert 1950, 1). Peckhouse makes the following remark: "the basic objects of his [Hilbert's] system of axioms are "thought-things", i.e., products of human thought (…). Geometry now becomes a speculative discipline, its relation to intuition becomes irrelevant, or, as Hans Freudenthal took it, the connection between the reality and geometry is cut" (Peckhaus 2003, 142).

Hilbert explains his approach in a letter to Frege in the following way: "every theory is only a scaffolding or schema of concepts together with their necessary relations to one another, and that the basic elements can be thought of in any way one likes. If in speaking of my points I think of some system of things, e.g., the system: love, law, chimney-sweep (…), and then assume all my axioms as relations between these things, then my propositions, e.g., Pythagoras' theorem, are also valid for these things. In other words: any theory can always be applied to infinitely many systems of basic elements" (Frege 1980, 40).

The step taken by Hilbert eventually shaped the manner of reasoning grounding its logic only on internal relationships, inferences. Such reasoning does not need any external references, and especially no justification based on experiences or even any relationship with the world (reality). It is based solely on the internal order adopted on the basis of the structure of axioms. Humphreys refers to this kind of technique as syntactic axiomatization (Humphreys 2004, 552). Murawski writes that "in this way geometry become pure mathematical theory. Axioms were not treated any longer as evident and necessary statements. The question about their truth lost its meaning and sense. As axioms any sentences could be adopted. The main problem was now not the problem of consistency of given axioms. Geometrical deductive systems became uninterpreted axiomatic systems various interpretations of which are possible. In this way, the traditional philosophical view which regarded geometrical knowledge as synthetic a priori knowledge of our world has been decisively refuted" (Murawski 2004, 582).

Also, the works of Richard Dedekind, Gottlob Frege, and Giuseppe Peano appearing in the second half of the nineteenth century and addressing numbers "did lead to a reshaping of mathematics if not the whole world-view" (Hodgkin 2005, 215). They brought about a "crisis of foundations" regarding the sense and the justification of essential mathematical beings. They lost their nature of intrinsic, self-contained beings that could be described, defined, or used: "the objects of mathematics were not actual things-in-themselves (as one thinks of a triangle, say, or the number "7"), but the rules which they obeyed" (Hodgkin 2005, 216). This meant a departure of mathematics from the world of experiments, and an immersion in a reality of almost any kind of abstract constructs. Many years later, Morris Kline referred to the situation as "the loss of truth": "By 1900 mathematics had broken away from reality; it had clearly and irretrievably lost its claim to the truth about nature, and had become the pursuit of necessary consequences of arbitrary axioms about meaningless things" (Kline 1990, 1035). Mathematics, viewed thus far as a stable structure, one making the world stable as well, changed into an unanchored balloon: untamed, unpredictable, and dangerous.

This, of course, led to a crisis that triggered a search for solutions and a need for fundamental questions and answers to problems concerning mathematics itself. Such circumstances give birth to the idea of a purely conceptual machine, acting as an important element of reasoning—not an actual, real object. An idea that will lie at the heart of a computer later on. The machine was invented by Alan Mathison Turing, named after his name and described in his famous 1936 article entitled *On Computable Numbers, with an Application to the Entscheidungsproblem* (Turing 1937). The machine is used to illustrate the dynamics of actions expressed as subsequent steps and taken in the form of manipulation of arbitrary symbols. These are simple steps as they actually involve only being written down and erased in some specific order. The steps are materialized as a mechanical procedure that moves forward by means of pre-assumed simple conditional rules: identify the symbol and erase it, change it, or leave it, and then move to the next symbol. The machine, simple yet highly ingenious and offering an incredible potential manifested in the interpretation of the symbols it utilizes, is a basic subject covered in all IT textbooks—including *Algorithmics. The Spirit of Computing*, a classic by David Harel (1987), reissued many times, where he wrote as follows: "Turing machines are capable of solving any effectively solvable algorithmic problem! Put differently, any algorithmic problem for which we can find an algorithm that can be programmed in some programming language, any language, running on some computer, any computer, even one that has not been built yet but can be built, and even one that will require unbounded amounts of time and memory space for ever-larger inputs, is also solvable by a Turing machine" (Harel and Feldman 2004, 228).

Turing's concept was an answer to the fundamental mathematical problem set by Hilbert mentioned earlier. During his lecture given at the Second International Congress of Mathematicians which took place in 1900 in Paris, Hilbert presented his famous program in the form of twenty three unsolved mathematical problems. The program was "an attempt to justify the classical (infinite) mathematics and to save its integrity by showing that it is secure" (Murawski 2010, 29). Implementing the program was to stabilize and justify mathematical procedures and constructs, and to be more precise—build the mathematical foundation upon a set of certain specific axioms and rules of inference. Problem 10, described in more detail by Hilbert 1928, came down to a question Penrose summarized as follows: "is there some general mechanical procedure which could, in principle, solve all the problems of mathematics (belonging to some suitably well-defined class) one after the other?" (Penrose 1999, 34).

Hilbert's program failed eventually when, in 1931, Gödel proved that it was impossible to establish such a system (Nagel and Newman 1958). Turing gave a negative answer to Hilbert's question asked under problem 10 as well. Penrose explained his line of reasoning in great detail, using a language that was far from mathematical. He summarized Turing's conclusion in the following words: "no algorithm exists for deciding the question of the stopping of Turing Machines" (Penrose 1999, 63). Similar conclusions were arrived at by Alonzo Church at a similar time, although he based his inference on a different line of thought.

When describing a Turing machine, Penrose resorted immediately to binary system as the relatively simplest symbolic system, which makes the machine a calculation tool at the same time. Modern computers are all based on a binary system. This is very convenient because the numbers can symbolize logical states (true and false), and numbers such as 1 and 0 become interpreted in logical terms. The application of logical calculus proposed by George Boole (1854; Davis 2000, 32) makes it possible to perform calculations on logical values. Moreover, in practice the existing boundaries become blurred. This quality is the basis of editing of a digital image, which is represented in the form of a stream of numbers encoded in a binary system. The same numbers can be used to perform logical operations such as obtaining a product or a logical sum. This is how many filters enabling the editing of digital images work. In the physical reality of a computer's operation, numbers and logical states take on the same form of manifestation—the differences in electric potentials.

But a mathematical binary system shall not be understood as merely a technical facilitation. A decision to utilize it involves more serious consequences. Consequences regarding the view of the world imposed by a given decision—a world fundamentally and transcendentally tied with numbers. Issues related to such type of context have accompanied binary system since its beginnings, appearing directly in the descriptive structures available throughout time. Ifrah covers the complex circumstances of the emergence of this system at length. The system is said to have been created by Leibniz, who saw it in the Chinese system of the *yin*