Digital Transformation as a Reconstruction of Knowledge

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Abstract: The subject of this paper is a description of the renew and more advanced idea of digital transformation, which is understood not as a contemporary process of the impact of digital technologies on social life, but as an epistemological change in geometry and mathematics in the 19th century. Turing machine was a result of this change as well as the new idea of axiomatic systems. The first brought back the concept of computability as an essence of the world, and the second was a new and arbitrary model of reasoning. Both changed the image of the social world.

Keywords: knowledge; digital transformation; mathematics; epistemology

1. Introduction

There is already very extensive literature on digital transformation, an abundance of which appeared in recent years when dozens of books were published on this topic. Although the first publications date back to least 2004 and even earlier [1], interest rapidly and intensively increased in 2016 and 2017. Google Trends shows a trend of increasing popularity from the beginning of 2014 to the present [2]. According to the author digital transformation as a subject of disciplined reflection appears in the literature in the following three basic variants: (1) as a description of a certain business and organizational reality of enterprises; (2) as a source of technological modernization of enterprises; (3) as a broader social, cultural or even psychological process. Numerous examples of literature can be found in [3].

The most common context for the description of digital transformation is business processes that directly address organization management problems. In 2015 Matt et al. already indicate the need for integration of “the entire coordination, prioritization, and implementation of digital transformations within a firm” [4] (p. 339). They also introduced a descriptive model based on the idea of “dimensions” of digital transformation, in their case management aspects, which was reproduced in other publications in other implementations, e.g. strategic assumptions of the enterprise [5], or the internal and external circumstances of its functioning [6].

Despite the similar dominant approaches in the literature, the issue of digital transformation cannot be limited to the narrow field of entrepreneurship and management, because this field is an immanent part of the wider social context of business. For example Ustundag and Cevikcan [7] refer to the economic and political project of the German government entitled Industry 4.0. Bartodziej juxtaposes the two concepts and notions appearing side by side, Industry 4.0 and the fourth industrial revolution, and lists the two technologies that establish them, which are cyber-physical systems and the Internet of Things and Services [8] (p. 2). Möller, describing cyber-physical systems, perceives both the idea of Industry 4.0 and the idea of the fourth revolution [9,10] as the most important basis, which are components of digital transformation [11].

Digital transformation as a process of rapidly spreading technology covers a huge area of phenomena resulting from its applications which is natural in the case of social processes.
Moreover, as one can expect, such phenomena can be organized, for example, according to the logic of social sciences, and may reveal themselves as anthropological, sociological, social-psychological, political, and economic phenomena [12].

2. Results

The reflection on digital transformation based on the aforementioned variants presents a pragmatic and even practical character. This approach, however, ignores the deep sources of the described social processes because digital transformation has deep roots in the epistemological breakthrough that emerged at the end of the 19th century. This breakthrough took place in the area of mathematics and geometry and concerned the way in which the models of reality are constructed. That way, of course, also included the basic understanding of science as an ordered and substantiated cognitive strategy. The approach developed as a result of the aforementioned breakthrough became the subject of epistemological reflection, both at the theoretical level, dealing with the philosophical interpretation of epistemic processes, and at the operational level, concerning the practical functioning of science and its methodological assumptions. For this reason, this breakthrough can also be considered as a process of reconstructing the idea of knowledge. Digital transformation can be understood as a result of the aforementioned epistemological breakthrough. As a phenomenon of epistemology, digital transformation also becomes a phenomenon of knowledge and transfers the reflection from the level of observation of direct social effects to a different, higher level.

The aforementioned breakthrough is a broad phenomenon in which the following three issues can be distinguished in this paper. The first issue covers the role of the so-called non-Euclidean geometries, which appeared in the first half of the nineteenth century and changed the understanding of the geometry of the world. The second issue involves the problem of number. This problem has emerged as the basic question about the meaning and ontological foundations of the number, evoking, at the same time, a stream of new interpretations. The third issue involves the emergence of the idea that the creation of formal mathematical systems is a completely arbitrary process and requires no justification in the outside world in the sense that it does not have to represent the outside world at all. These systems have their predetermined order, which is quite sufficient to justify them. Paradoxically, they can lead to an interpretation of this world in an inverted order of reasoning i.e. from system to reality, thus overcoming any limitations of analysis based on observation or experience.

These three issues are the basis for changing the way world phenomena are interpreted, introducing the new role of mathematics and also leading to an understanding of the role of digital technologies. Firstly, the position of descriptive tools concerning these phenomena was changed. They were liberated from the necessity to represent these phenomena, which was previously treated as a necessary point of reference and the basis for the verification of all descriptive constructions. Secondly, within the discussion of new, evolving ideas for creating these constructions, an idea appeared, laid down by Turing in his famous 1936 article with a significant title, “On Computable Numbers, with an Application to the Entscheidungsproblem”. This idea described a conceptual machine, which is “a simplified abstract model of computation” [13] (p. 325), this conception is realized in the form of a real electronic device—the computer. The title “Entscheidungsproblem” referred to the metamathematical and abstract discussion started by Hilbert about the possible existence of an automatic procedure for validating mathematical proofs. However, most of Turing’s text was devoted to the problem of “computable numbers” and the problem of computability, laying the foundations not only for a technical device but also for a new strategy in the way of approaching world phenomena, as well as shaping and managing them.

Digital transformation can, therefore, be interpreted as the process of implementation of the change in the epistemological paradigm (and, thus, the “nature” of knowledge) on the “mathematical” (and, in this sense, digital) but in a completely different sense than the previous paradigm (coming, for example, from Galileo). It reverses the relationship of this range.
between mathematics, as an epistemological approach, and the world, making mathematics a self-sufficient area of creation. The knowledge that appeared as a result of this reversal has a specific and so far poorly described character.

Transferring the analysis of digital transformation to the level of knowledge enables the use of new descriptive constructions related to knowledge. One of such constructions is proposed by the theory of discursive space. It is based on the idea of knowledge proposed by Michel Foucault, in which knowledge is realized as a discourse (discourses). According to this theory, knowledge is a set of discourses traversing a multidimensional dynamical space in time. This space becomes a model of knowledge about digital transformation, answering the question of what this transformation is.

3. Discussion

Digital transformation as a result of the aforementioned epistemological upheaval leads us towards a certain paradox, the parts of which are, on the one hand, free axiomatic systems, which can be treated as detached from reality, and, on the other hand, computability, which becomes the axis of the discussion on the essence of reality as a computable structure, i.e. a mathematical entity. Reasoning based on the idea of loosening and even rejection by mathematical constructions of the relationship between mathematics and the real world appeared in the concepts of Peano first, and then of Hilbert. The source of Peano’s thoughts was the concept of a natural number that he believed to be “an undefined notion which is characterized axiomatically” [14] (p. 68), which led to the idea of free, ungrounded rules in the real world, creating a coherent axiomatic system.

Hilbert developed an analogous idea on the grounds of geometry, which underwent a particularly intense transformation in the nineteenth century, breaking away from the prevailing Euclid interpretation, which was so well suited to everyday experience. The emerging geometries of Łobaczewski and Bolai propose different constructions, inconsistent with this experience, and open the way to the free construction of geometry. Murawski writes that “in this way the traditional philosophical view which regarded geometrical knowledge as synthetic a priori knowledge of our world has been decisively refuted” [15] (p. 582). Peckhaus adds that “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” [16] (p. 142). Kline describes the situation of mathematics, which is the universal basis of natural science, so dramatically experienced by the ideas of Peano, Hilbert, and others, in the following way: “By 1900 mathematics had broken away from reality; it had clearly a dirretrievably lost its claim to the truth about nature, and had become the pursuit of necessary consequences of arbitrary axioms about meaningless things” [17] (p. 1035). In this way, a completely new epistemological pattern was created, the source of which was not the world, but free thought, which was the image of artificial and abstract constructions. It can be said that the obstacles coming from the nature of the human thought have finally been overcome, e.g. the so-called idols already described by Francis Bacon in Novum Organum in 1620.

On the other hand, computability is also discovering the “true” nature of the world, even as a field for the realization of the laws of thermodynamics—formulated as computable equations that are universally and necessarily valid. The problem of computability as a universal property and, at the same time, a way of description became the subject of lively discussion in the second half of the twentieth century, focusing, in particular, on the following two mechanisms that were initially considered particularly complex Turing machines: the human brain and the physical universe. Petzold provides a comprehensive summary of this discussion [13]. Computability, however, can also function as a certain interpretive pattern to capture and reproduce the world. At the same time, this pattern is realized as a certain social and cultural norm, enabling new processes. Among them, there are, for example, two new, complementary spaces of social processes and phenomena related to the concepts of virtuality and simulation.
However, of key importance is the possibility, opened as a result of a mathematical upheaval, to interpret the world in an almost arbitrary way, i.e. avoiding the condition of compatibility with the outside world, which also allows rejection of the requirement of truth, understood as a necessary condition of description, leading to a single, valid interpretation. Therefore, legitimate descriptions are competitive and numerous, as well as local, in the sense of the applied assumptions and rules. This means a change in the very core of epistemological processes, which appears in various ways in philosophical and social reflection, both in terms of a disciplined description of the world of a scientific nature and common knowledge. This change reveals itself, for example, as a broad and diverse project of relativizing the knowledge in relation to social determinants.

An example of a concept based on such assumptions is the so-called discursive space. It is based on the assumption that higher-order linguistic structures, such as discourses, store and articulate knowledge over the course of the social and historical processes of their formation. This idea, developed by Michel Foucault, has become the basis for the construction of a multidimensional dynamic space in which discourses follow trajectories that determine the state of knowledge about the world, described by the terms [18–20]. According to this theory, digital transformation is a kind of entanglement of many discourses, covering various issues, such as those mentioned in the Introduction. The dimensions of dynamic space are the result of a qualitative analysis of these discourses.

The concept of digital transformation refers to the digit (or the number—this conceptual confusion has its story [3]), the way of existence and the history, which are particularly complicated and ultimately inconclusive. Attempts to define the number and its ontological basis were made by the above-mentioned Frege, Dedekind, and Peano at the end of the nineteenth century, but they did not lead to clear conclusions. At the same time, on the other hand, nowadays the number is a “despotic ruler”, as Badiou writes, pointing to its numerous fields of use [21]. The domains in which the number prevails are politics, the so-called humanities, cultural representations, and economics, although we do not have a good, current, and functioning idea of it, which must lead to the following pessimistic conclusion: “we don’t know what a number is, so we don’t know what we are” [21] (p. 3). The interpretation of the number, and more broadly of mathematics as the field of its analysis and application, presented by Badiou is metaphysical and indicates its fundamental nature, which is described as follows: “Number is neither a trait of the concept, nor an operational fiction; neither an empirical given, nor a constitutive or transcendental category; neither a syntax, nor a language game, not even an abstraction from our idea of order. Number is a form of Being. More precisely, the numbers that we manipulate are only a tiny deduction from the infinite profusion of Being in Numbers” [21] (p. 216). Such an interpretation emphasizes the special importance of the number as an emanation of a multitude that determines the conditions for the functioning of the world. Mathematics, therefore, appears in a new way as a specific and extremely basic insight into reality, which is based on a specific ontology constructed on the idea of a multitude that directly relates to the number as its basic structure. The idea of Badiou is, therefore, also understood as one of the most advanced analyses of the contexts of digital transformation, following the meaning proposed here. This concept also brings perhaps the most advanced analysis of the context of the existence of a computer.

4. Conclusions

The concept of digital transformation is by no means old or worn out, quite the contrary. Interest in it, as shown by the number of books published in recent years, is very high. However, this extensive reflection is mainly empirical and comes down to an interpretation based on technological determinism, i.e. it considers the processes and events to be the results of the emergence of digital technology in its various variants, i.e. the computer. This approach has a fundamental flaw, which was noticed many years ago in the context of the so-called new media—it adopts one direction of influence arbitrarily, significantly reducing the complexity of social processes.
The approach to the problem of digital transformation presented in this paper proposes to shift the analysis from the level of ad hoc and pragmatic observation of the social situation caused by the emergence of digital technologies to a higher level, where this transformation is treated as a phenomenon of knowledge. At this level, one can observe significant changes in the understanding of the way the world is perceived, which continue to affect the social processes described by the empirical approach. The aforementioned changes take place in the area of geometry and mathematics and concern the construction of models that further describe the world, for example in the form of equations. The change in question is profound and comes down to a reversal of the order of reasoning, whereby the empirical approach appears at the end, while the theoretical part is a product of free thought, fulfilling certain strict conditions of inference.

At the same time, the same historical change allowed for the emergence of the Turing machine as a conceptual model of the computer, which brought back attention to the problem of computability as an inherent quality of the world, which has existed at least since the time of Galileo. Computability is, on the one hand, the subject of ontological considerations, but on the other hand, it is a source of models shaping physical and social phenomena, and in this sense, it has a direct impact on social reality.

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References
1. Stolterman, E.; Fors, A.C. Information Technology and the Good Life. In Information Systems Research: Relevant Theory and Informed Practice; Kaplan, B., Truex, D.P., Wastell, D., Wood-Harper, A.T., DeGross, J.I., Eds.; Springer: Boston, MA, USA, 2004; pp. 687–692. ISBN 978-1-4020-8095-1.
2. Google Google Trends. Available online: https://trends.google.com/trends/explore?date=all&q=digital%20transformation (accessed on 22 January 2022).
3. Maciag, R. Transformacja Cyfrowa. Opowieść o Wiedzy; TAiWPN Universitas: Kraków, Poland, 2020.
4. Matt, C.; Hess, T.; Benlian, A. Digital Transformation Strategies. Bus. Inf. Syst. Eng. 2015, 57, 339–343. [CrossRef]
5. Bharadwaj, A.; El Sawy, O.A.; Pavlou, P.A.; Venkatraman, N.V. Digital Business Strategy: Toward a Next Generation of Insights. Manag. Inf. Syst. Q. 2013, 37, 471–482. [CrossRef]
6. Bounfour, A. Digital Futures, Digital Transformation: From Lean Production to Acceluction; Progress in IS; Springer International Publishing: Cham, Switzerland, 2016; ISBN 978-3-319-23278-2.
7. Industry 4.0: Managing the Digital Transformation; Ustundag, A.; Cevikcan, E. (Eds.) Springer Series in Advanced Manufacturing; Springer International Publishing: Cham, Switzerland, 2018; ISBN 978-3-319-57869-9.
8. Bartodziej, C.J. The Concept Industry 4.0. An Empirical Analysis of Technologies and Applications in Production Logistics; Springer Fachmedien Wiesbaden GmbH: Wiesbaden, Germany, 2017; ISBN 978-3-658-16301-7.
9. Schwab, K. The Fourth Industrial Revolution; Crown Business: New York, NY, USA, 2016; ISBN 978-1-5247-5886-8.
10. Schwab, K.; Davies, N. Shaping the Fourth Industrial Revolution; World Economic Fund: Geneva, Switzerland, 2018; ISBN 978-1-944835-14-9.
11. Möller, D. Guide to Computing Fundamentals in Cyber-Physical Systems: Concepts, Design Methods, and Applications; Springer International Publishing: Cham, Switzerland, 2016; ISBN 978-3-319-25176-9.
12. Nisbet, R.A. Social Science|History, Disciplines, & Facts|Britannica.Com. Available online: https://www.britannica.com/topic/social-science (accessed on 12 October 2018).
13. Petzold, C. The Annotated Turing: A Guided Tour through Alan Turing’s Historic Paper on Computability and the Turing Machine, 1st ed.; Wiley: Indianapolis, IN, USA, 2008; ISBN 978-0-470-22905-7.
14. Gillies, D. Frege, Dedekind, and Peano on the Foundations of Arithmetic; Van Gorcum & Co.: Assen, The Netherlands, 1982; ISBN 978-1-136-72107-6.
15. Murawski, R. Mathematical Knowledge. In Handbook of Epistemology; Niiniluoto, I., Sintonen, M., Wolteriski, J., Eds.; Springer: Dordrecht, The Netherlands, 2004; pp. 571–606, ISBN 978-1-4020-1986-9.
16. Peckhaus, V. The Pragmatism of Hilbert’s Programme. Synthese 2003, 137, 141–156. [CrossRef]
17. Kline, M. *Mathematical Thought from Ancient to Modern Times*; Oxford University Press: New York, NY, USA, 1990; Volume 3, ISBN 978-0-19-506137-6.

18. Maciag, R. The Analysis of the Internet Development Based on the Complex Model of the Discursive Space. *Information* 2018, 9, 7. [CrossRef]

19. Maciag, R. Discursive Space and Its Consequences for Understanding Knowledge and Information. *Philosophies* 2018, 3, 34. [CrossRef]

20. Maciag, R. Ontological Basis of Knowledge in the Theory of Discursive Space and Its Consequences. *Proceedings* 2020, 47, 11. [CrossRef]

21. Badiou, A. *Number and Numbers*, 1st ed.; Polity: Cambridge, UK, 2008; ISBN 978-0-7456-3879-9.