The Evolution of Digital Transformation

Cheng Gong, Xavier Parisot, and Detlef Reis

Abstract The evolution of digital transformation (DT) poses a significant challenge for organizations worldwide, representing both disruptive difficulties and tremendous opportunities for renewing value offerings, business models, and organizational practices. To use DT as an impetus for positive change, however, it is critical that scholars and practitioners have a clear, unified understanding of the concept. We structure our discussion as follows: Sect. 1 of this chapter discusses the confusion around the concept "digital transformation" and its related concepts (i.e., digitization, digitalization). Section 2 presents the etymology of these three concepts', leading to a discussion of the main etymological reasons behind the confusion. In the Sect. 3, we explore the historical use of these concepts in the pertinent literature; we reveal how scholars have interpreted the concepts inconsistently and associated them with a myriad of different realities/phenomena. Section 4 introduces a concept formation and assessment methodology to lay the theoretical foundation of how concepts can be analyzed and assessed. Section 5 offers a collection of existing definitions of digitization, digitalization, and digital transformation that we selected to analyze their defining attributes. We present a detailed example of how we systematically analyzed and assessed digitization's historical defining attributes. We then report the results of the same analysis for digitalization and digital transformation to assuage the "fuzziness" issue associated with these concepts. Section 6 sums up and discusses our findings that we hope will inspire academics and practitioners to use these terms carefully and consistently.

Keywords Digital transformation · Digitalization · Digitization · Concept evolution · Reconceptualization

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D. Schallmo et al. (eds.), *Digital Disruption and Transformation*, Springer Proceedings in Business and Economics, https://doi.org/10.1007/978-3-031-47888-8_1

1 Introduction

World Economic Forum (2017) acknowledged digital transformation as one of the world's most pressing challenges for most organizations. Digital transformation (DT) is challenging how organizations can better meet evolving customer expectations, deliver their value propositions, and respond to a changing living and working environment. The growing penetration of digital technologies in the market inevitably drives organizations to rethink their value chain and draw up a roadmap to successfully embark on the "going digital"-journey. While there is general agreement on its growing importance to an organization's success, the inconsistent use of the term "digital transformation" in academia and business practice generates confusion.

On the academic front, the definitional inconsistency of digital transformation and its related terms (e.g., digitization, digitalization) and the theoretical inconsistency of its implications at multiple levels of analysis hamper the betterment of research. The co-existence of numerous conflicting definitions has rendered these terms meaningless. It creates difficulties in developing a consistent stream of research that builds on what has been done before, thus making it more complicated to define and test relationships for digital transformation theory building (Gong and Ribiere 2021). The vagueness in the literature demonstrates a lack of a comprehensive, unified understanding of digital transformation (Goerzig and Bauernhansl 2018; Haffke et al. 2016; Matt et al. 2015; Morakanyane et al. 2017; Van Veldhoven and Vanthienen 2019). This lack of a homogeneous interpretation of the concept is detrimental to research synergy, leading to wildly contradictory and incompatible research findings unfit to guide business practice.

On the practical front, digital transformation appears to be one of the top priorities on business leaders' agendas (Sundblad 2020). However, a McKinsey (2018) study found that the success rate for implementing DT in organizations is less than 30%; moreover, among those organizations reporting a successful implementation, only 23% improved their organizational performance, and in only 7% of cases were these improvements deemed sustainable. The success rates do not exceed 26% in digitally savvy industries (e.g., high tech, media, and telecom) and fall between 4 and 11% in more traditional industries (e.g., oil and gas, automotive, infrastructure, and pharmaceuticals; De la Boutetière et al. 2018). IBM claims that successful digital transformation took around four years and observed that 85% of efforts fail (Gibson 2018). Moreover, Gartner (2019) predicted that through 2021, digital transformation initiatives would take large traditional organizations, on average, twice as long and cost twice as much as initially anticipated.

Leaders and executives using the term DT inconsistently to describe various strategizing and organizing activities (Warner and Wäger 2019) may risk blurring the distinct direction of organizational strategic moves (e.g., aiming for incremental vs. radical changes). Having an unclear DT vision challenges C-suite managers in claiming authority and clearly defining job responsibility for digital-related projects at the organizational level. Having diverse interpretations of DT makes it harder

to benchmark one's performance against other organizations and industries on DT metrics and best practices at the industrial level.

2 Concepts' Etymology

Exploring the etymology of a term is crucial in concept formation since it reveals all the historical connotations contained in a particular term and opens up "a whole new understanding of the true reality" (Eriksson 2010, p. 5). Indeed, the origin, derivation, and historical evolution of a term explain the multivalence of its meanings, i.e., the multiplicity of its definitions (Gerring 1999). This definitional plurality generates a halo of meanings that can affect how common people, managers, and scholars understand a concept "at first sight." Therefore, a comparison between the existing meanings and the one retained for the conceptual definition is informative in concept formation studies (Eriksson 2010). It helps discriminate between the terms' historical meanings, the actual meanings shared in common languages, and the meaning chosen by scholars. Moreover, the diversity of accepted meanings in the common language helps understand the size and scope of the term's "halo effect" (Dumez 2011) chosen to denominate the concept. The meaning of the term(s) chosen in the seminal definition(s) also determines what kinds of empirical cases the concept applies to, how far this application should go, and where it should stop. In other words, the concept's meaning determines its empirical domain of validity.

The words digital and digitize share a common Latin root: "digit." This term emerged in ancient Latin (1st Century BC) *digitus* originally means "finger or toes," and evolved into modern Latin (since about 1500) *digitalis* means "fingers." The modern use of the term "digital" as an adjective, meaning "of signals, information, or data: represented by series of discrete values (commonly the numbers 0 and 1), typically for electronic storage or processing" started from 1940 (OED 2010). George Stibitz first used the term in 1942 in the expression "digital computer" as a counterpart to the analog (Aspray 2000). "Digital" also means "of a computer or calculator: that operates on data in digital form; (of a storage medium) that stores digital data" (since 1945); "of technologies, media, etc.: involving digital data; making use of digital computers or devices" (since 1948; OED 2010). These historical meanings of the word "digital" laid the foundation of the modern use of the verb "digitize," referring to "converting into a sequence of digits in computer programming, moving from analog number to electronic digits" (since 1953; "Online Etymology Dictionary" n.d).

Etymologically, the word "digitization" is clearly rooted in the verb "digitize," while the word "digitalization" comes from the same Latin root "digital," which serves as one component of the concept "digital transformation." This etymological word commonality inevitably generates confusion between the meanings of these terms, which leads to an interchangeable use of the different terms in both academia and practice. All the concepts discussed above are using common language terms for their concept formation. The multivalent meanings of these terms also blur the

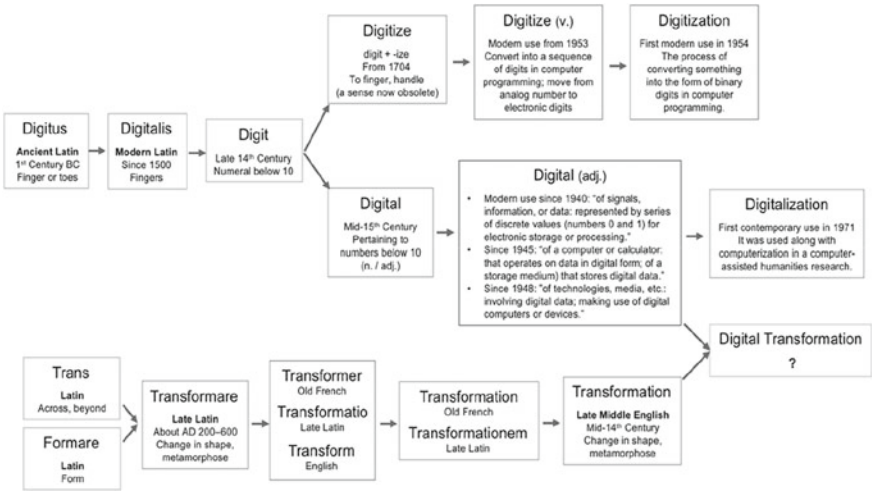

Fig. 1 Etymology of digitization, digitalization, and digital transformation (*Source* Own illustration)

specificities of each concept. Therefore, discrimination between digitization, digitalization, and digital transformation is more challenging to achieve from a common language perspective. While this common denomination strategy improves these terms' familiarity, it decreases the ability to discriminate the concepts. The following exploration of the intension and extension of each of these concepts could solve that matter.

We present a summary of the etymology of the terms digitization, digitalization, and digital transformation (see Fig. 1). A more detailed etymological analysis of these terms can be found in section Appendix 1.

3 The Historical Use of the Concepts

Understanding the history of a concept's formation is critical to recognize the evolution of its scope and limits of application. This history starts with the seminal definition(s) of the concept and continues with the evolution of that definition when confronted with multiple empirical realities. As for digitalization and digital transformation, this historical analysis is critical to explaining the sources of confusion that resulted in the shared common etymological roots. It reveals the definitional overlap and distinctions between these three terms and allows to retrace the chronological emergence of their associated core attributes and auxiliary hypothesis (Lakatos 1978).

3.1 Digitization

The Oxford English Dictionary (OED) traces the first modern use of the term "digitization" jointly with computers to the mid-1950s (OED 2014). According to the OED, digitization refers to "the action or process of digitizing; the conversion of analog data (especially in later use images, video, and text) into digital form." Some scholars refer it to the technical process of converting analog data into a digital format: an array of zeros and ones stored in a way that makes them readable by computers. With the technological development, the creation, storage, communication, and consumption of information and non-digital products are all being gradually digitized (Press 2015). The development of digital technologies and their implications in different fields have compelled scholars and practitioners to explore digital technologies' potential, extending from the technical process to their impact on different entities (i.e., organizations, businesses, industries, societies).

A Google Trend search by Seibt et al. (2019) indicates that the term digitization used to be more popular in English-speaking countries, while the term digitalization has been more frequently searched for in continental Europe. No distinction is widely represented in dictionaries, such as the Oxford dictionary, which offers the same definition for both terms. The Encyclopedia Britannica ("Encyclopedia Britannica" n.d.) and sociological dictionaries (Bruce and Yearley 2006; Scott and Marshall 2009; Swedberg and Agevall 2016; Turner 2006) do not define the terms digitization and digitalization. However, both terms are applied in business contexts, public debates by media (Seibt et al. 2019) with correlated meanings that have been causing a great deal of confusion.

In the academic literature, no single seminal scientific definition that all the authors agree upon can be found for each of these concepts. Moreover, all the definitions of digitization are rooted in common language, not in systematic scientific conceptualization. Digitization and digitalization terms are often applied to signify the same objects/phenomenon. The same overlap exists between the use of the term digitization and the term digital transformation. Some authors use different terms interchangeably consciously or unconsciously; others may differentiate one concept while using the other two terms as equivalents implicitly or explicitly. Such confusion or lack of a common conceptual basis makes it impossible to ensure cumulative and sustainable knowledge creation (Sparrowe and Mayer 2011). Consequently, this lack of clarity leads some authors to distinguish these three terms and their associated definitions in their articles to attach one specific term to one specific object/phenomena (e.g., Mergel et al. 2019; Verhoef et al. 2019).

3.2 Digitalization

The first contemporary use of the term "digitalization" along with computerization appeared in Wachal's (1971) essay that discusses the social implications of

the digitalization of society in computer-assisted humanities research (Brennen and Kreiss 2016). In general, digitalization refers to "the use of digital technologies" (Srai and Lorentz 2019, p. 79). It "loses its more technical aspects to digitization while maintaining the vague ideas of restructuring social life or business, and all the normative connotations they entail" (Seibt et al. 2019, p. 10). Dijk van Jan (2006) noted that digitalization "allows a considerable increase in the production, dispersion, and consumption of information and the signals of communication" (p. 193), and "produces a culture of speed because creative production is assisted by the power of accelerated processing and distribution in computers and networks" (p. 209).

Digitalization is often used as a synonym of digital transformation when describing changes brought by the adoption of digital technologies in society and organizations. Besides, Seibt et al. (2019) argued that the discussion around the digitalization of industry is a debate that got labeled "Industries 4.0," which is the most prominent field of the industrial application of digitization, digitalization, and automation (Schumacher et al. 2016). Bloomberg (2018) noted that "automation is a major part of the digitalization story, whether it be shifting work roles or transforming business processes generally" (p. 4).

The implementation of IT tools/software in organizations, such as MRP (Material Requirements Planning), Manufacturing Resource Planning (MRP II), ERP (Enterprise Resource Planning), and BPR (Business Process Reengineering), leads to the first generation of digitalization processes. During the 1970s and 1980s, with computer hardware and software development, MRP and MRP II emerged, driven by the need for stronger integration between the functional enterprise silos, the suppliers, and the customers. From the 1990s, ERP (i.e., the adoption of standard software packages) and BPR (i.e., business management initiatives striving for process efficiency supported by IT) started to emerge and spread. ERP is a "framework for organizing, defining, and standardizing the business processes necessary to effectively plan and control an organization so the organization can use its internal knowledge to seek external advantage" (Blackstone and Cox 2005, p. 38). This dictionary definition resonates obviously with the expected outcomes of digitalization. The common aim/goal is to optimize organizations' existing business processes through efficient coordination between routines (Pagani and Pardo 2017). Organizations may undertake a series of digitalization projects to automate processes and increase process efficiency (Bloomberg 2018).

For the practitioners, digitalization refers to "the use of digital technologies and data (digitized and natively digital) to create revenue, improve business, replace business processes (not simply digitizing them) and create an environment for digital business" (i-scoop 2016), and "using digital technologies to automate processes for better outcomes and to optimize value" (NCMM 2020). For scholars, digitalization refers to "the adoption of Internet-connected digital technologies and applications by companies" (Pagani and Pardo 2017, p. 185), and "a means to fulfill customers' needs more effectively, adapt to changes in the sector and increase their competitive advantage" (Rachinger et al. 2019, p. 1150).

In digitalization, digital technologies serve as enablers for organizations to change their existing business processes (Verhoef et al. 2019), including communication

(Ramaswamy and Ozcan 2016; Van Doorn et al. 2010) and distribution (Leviäkangas 2016). To achieve such goals, organizations may use ERP or other digital technologies to support the digitalization process. The changes ERP introduced are primarily limited to business processes within organizational boundaries in efficiency improvement, cost reduction, and business process optimization (Ash and Burn 2003; Kauffman and Walden 2001), mainly focusing on deploying internal management information systems (Boersma and Kingma 2005). ERP and BPR put effort into exploiting IT software packages to improve organizational processes, focusing on production effectiveness and efficiency internally. Digitalization emphasizes the change process as a whole to achieve economic-driven outcomes through ERP or BPR and other digital technologies.

3.3 Digital Transformation

There is no common consensus regarding the seminal scientific definition of digital transformation in the literature. Historically, the ideas of digital products, services, and mediums can be traced back to the 1990s and 2000s (Auriga 2016; Schallmo et al. 2017). Morton (1991) noted that organizations experience fundamental transformations for effective IT implementation. This idea gave birth to a research stream studying IT-enabled organizational transformation, which may be seen as one of the scholarly roots of DT research (Nadkarni and Prügl 2020). It initiated DT's discussion with a strong IT focus as a catalyst of the information revolution (Gates et al. 1995) in the context of the Information Society's age and global competition. Therefore, at the early stage, a strong emphasis was put on the "digital" part – the use of digital technologies, providing a limited understanding of the "transformation" part of an entity. Thus, oftentimes, the concept of DT was used, or probably misused, synonymously with the one of digitization (the technical process) and digitalization (the installation process). With the accelerating development of digital technologies since the 1940s, industrial changes and societal developments throughout the previous decades could be witnessed, thus giving more importance to the transformational part of DT.

People then started to associate DT with the changes that digital technologies cause or influence in all aspects of human life (Stolterman and Fors 2004). The "transformation" part of DT, which was undervalued, gradually came back to attention. As different research streams started to emerge, some scholars gradually realized that DT is more than just a technological shift (Henriette et al. 2015). Apart from technology, it requires "actors" (Nadkarni and Prügl 2020) and the alignment of strategy and other factors, such as culture, mindset, talent development, and leadership (Goran et al. 2017). In recent years, some researchers have been concentrating on identifying DT's dimensions and drivers (Liere-Netheler et al. 2018a, b; Verhoef et al. 2019) as follows:

- **External drivers encompass:** (1) innovation push and market pull generated by the adoption and development of digital technologies (Nambisan et al. 2017; Sambamurthy et al. 2003); (2) increasing volume of data (Kouroubali and Katehakis 2019; Pappas et al. 2018; Zaki 2019); (3) accelerating customer behavior changes (Rogers 2016; von Leipzig et al. 2017; Westerman et al. 2014); and (4) laws/government policies adjustments (Gong et al. 2020; Nambisan et al. 2019), etc.
- **Internal drivers include:** (1) strategic imperative, such as, process and workplace improvement (Henriette et al. 2016); (2) vertical and horizontal integration (Camarinha-Matos et al. 2019; Gölzer and Fritzsche 2017; Borangiu et al. 2019; Liere-Netheler et al. 2018a, b); (3) management support (Matt et al. 2015; Vukšić et al. 2018); and (4) cost reduction (Liere-Netheler et al. 2018a, b), etc. Some other scholars focus on the positive and negative impacts of DT.
- **Positive consequences contain** (1) decision making improvement (Heilig et al. 2017; Roedder et al. 2016); (2) competitive advantage creation (Korhonen and Halen 2017; Schwertner 2017); (3) value creation enhancement, e.g., optimize customer experiences (Rogers 2016), etc.
- **Negative consequences cover** Cybersecurity (Möller 2020) and privacy (Mendhurwar and Mishra 2019), etc.

Beyond these new research directions, debates regarding the true nature of DT are ongoing. The controversy may be fundamentally founded in the fact that the range of DT definitions vary from: a slight technology-enabled change such as implementing a new ERP System (Chanias 2017) to a more radical and evolutionary process that takes place over time (Janowski 2015; Loebbecke and Picot 2015; Wang et al. 2018) or the economic and societal effects of digitization and digitalization (OECD 2018). While some researchers associate DT with business models (Berman 2012; Bharadwaj et al. 2013; Gassmann et al. 2014; Schallmo et al. 2017) and strategy (Bharadwaj et al. 2013; Henriette et al. 2015; Matt et al. 2015; Rogers 2016; Westerman 2018), others view DT as a paradigm or as a process (Berman 2012; Janowski 2015; Wang et al. 2018). As a result, the growing diversity of research fields associated with the concept of DT complexifies its clarification.

3.4 Synthesis

Historically, the three terms digitization, digitalization, and digital transformation are interconnected and describe different objects or phenomena. Digitalization with a longer history of use in the literature than digital transformation inevitably encompasses the early discussion of digitization's social impact and the later discussion of digital transformation's result. The absence of prevalent academic definitions for these three concepts is rooted in their ontogenesis, which was multivalent and parallel. Then, the multiplicity of connections between these concepts and others leads to a broad diversity of parallel theorizations. While this situation enriches the spectrum

of digital transformation research programs (Lakatos 1978), it does not clarify the concepts.

Multiple theorizations based on multiple conceptual definitions hinder the scientific community's ability to better define and connect all the objects involved in digital transformation, i.e., to standardize and generalize their research strategy. Therefore, the possibility of comparing different results from different studies is very limited in the current situation. It implies that authors of academic papers should first consider the connections applied between the chosen terms, the definitions, and the objects or phenomena under scrutiny.

Apart from its truly intended meaning, digitalization has also been used to describe digitization in some cases and digital transformation in other cases. Some authors such as Verhoef et al. (2019) view the terms in a sequential order (digitization → digitalization → digital transformation) with digitalization bridging and connecting the other two terms; other scholars disagree with this view. The situation is further complicated when linguistically translating digitalization and digital transformation as one word in some languages to explain the change and its end-results of using digital technologies, not the technical process.

Digitalization is used to depict a state of being digitalized and the process whereby the entities are affected by the action of "going digital." Today's consensus seems that digital transformation is more than digitization (Haffke et al. 2016; Iansiti and Lakhani 2014; Yoo et al. 2012). According to a scoping review of Verhoef et al. (2019), most of the literature subscribes that digitization and digitalization imply more incremental phases to attain the most pervasive phase of digital transformation (Loebbecke and Picot 2015; Parviainen et al. 2017a, b). However, the inconsistent use of digitalization and digital transformation still exist in a broad range of academic and practitioner literature. And a disconcerting limitation of the existing literature is the failure to distinguish them properly.

4 The Concept Analysis Methodology

Based on Ogden and Richards (1923) semantic triangle (i.e., symbol, thought/reference, referent) and on Sartori's (1984) work (i.e., term/word, meaning, referent/object), Gerring (1999) proposed eight in-depth criteria of conceptual goodness: familiarity, resonance, parsimony, coherence, differentiation, depth, theoretical utility, and field utility. Gerring (1999) supports Ogden and Richards (1923) view that concepts are good when they attain a proper alignment between the three dimensions of intension, extension, and term (pp. 357–358) (see Fig. 2):

- **The term** refers to the words allocated to a concept as a label covering both the intension and the extension. It impacts the level of familiarity, resonance, and field utility of the concept.

Criteria	Explaination	Rating Scale					
Familiarity	The degree to which a new definition "makes sense," or is intuitively "clear," depends critically upon the degree to which it conforms/clashes with estabilished usage.	0 Definition clashes with established usage	1	2	3	4	5 Definition conforms with established usage
Resonance	The "cognitive click" of a given term.	0 No "cognitive click"	1 Low	2 Fair	3 Normal	4 High	5 Max "cognitive click"
Parsimony	The length of the definition (number of defining attributes) while concisely defining a concept.	0 ≥ 15 attributes	1 13~14	2 11~12	3 9~10	4 7~8	5 ≤ 6 attributes
Coherence	The sense in which the attributes that define that concept, and the characteristics that actually characterize the phenomena in question, "belong to one another."	0 Attributes are not logically or functionally related	1	2	3	4	5 Attributes are logically or functionally related
Differentiation	It refers not only to semantic space (i.e., the degree to which a concept's definitional borders are clear) but also to physical space (i.e., the degree to which a concept's borders in time and space are clearly demarcated).	0 No clear boundaries from/overlap with other concepts	1	2	3	4	5 Clear boundaries from other concepts; the concept is sufficiently bounded
Depth	The depth and utility of a concept is enhanced by its ability to "bundle" characteristics. The greater the number of properties shared by the phenomena in the extension, the greater the depth of a concept.	0 Limited number of properties shared by the phenomena	1	2	3	4	5 A great number of properties share by the phenomena
Theoretical utility	The concept's usefulness in theory formulation (i.e., to formulate new theories or refine existing).	0 Useless in theory formulation	1	2	3	4	5 Usefull in theory formulation
Field utility	The disruption that concept formation can do to the rest of the "semantic/phenomenal field" in which academic work.	0 Damage the semantic field the concept enters	1	2	3	4	5 Enrich the conceptual quality of existing concepts in the field

Fig. 2 Concept goodness assessment rating scale (*Source* Own illustration). *Notes* The eight criteria of concept goodness are adapted from Gerring (1999)

- **The intension**, i.e., connotation, meaning, definiens, or definition, refers to the properties or attributes that define a concept. The attributes specifically chosen to define the concept establishes its level of parsimony and internal coherence.
- **The extension**, i.e., denotation, referent, object, definiendum, refers to the object, event, or phenomenon to be defined and the referent or referents to which a concept applies. It determines the nature of the empirical cases a concept applies to and impacts the concept's theoretical utility and depth. It determines a concept's level of differentiation.

Exploring the evolution of definitions reveals: (1) the multiplicity of definitions proposed in the literature; (2) to what extent their defining attributes overlap between the three concepts: digitization, digitalization, and digital transformation; (3) the plurality of conceptual boundaries and therefore of realities under scrutiny. It allows specifying the core and peripheral defining attributes used to define the three concepts. The defining attributes can then be grouped to analyze their logical alignment (internal coherence) as well as their external differentiation. Hence, such an analytical process facilitates a qualitative evaluation regarding the connections between the three dimensions of the semantic triangle and assesses the conceptual goodness of the targeted concepts using a rating scale adapted from Gerring's (1999) framework (see Fig. 2).

5 The Defining Attributes Analysis and Conceptual Assessment of the Relevant Terms in the Literature

5.1 Digitization

Definitions of digitization are collected until saturation/repetition of the defining attributes is observed. This process ensures that most of the applied defining attributes are identified. Saturation was achieved with 11 definitions. These key definitions of digitization evolved over the past two decades since the first definition was proposed in 1995 (and are presented in Appendix 2).

We summarize the 27 defining attributes of digitization and their frequency in Table 1. Based on the accumulated frequency of these attributes, the first five defining attributes are the core defining attributes (most frequent); the following 3 defining attributes are the peripheral (average frequency); and the rest are the outsiders (low frequency).

The analysis shows that digitization refers to a technical process of converting analog data/information[1] into digital forms. It is a process that has both symbolic (i.e., converting analog data into bits represented as 0 s and 1 s) and material (i.e., artifacts used to store and communicate digitized information) dimensions. Hence, through digitization, data is deconstructed and encoded as strings of 0 s and 1 s that "can then be expressed in many different ways, on many different types of materials, and in many different systems" (Brennen and Kreiss 2016, p. 2) as information. The ultimate characteristic of being stripped of errors, repetitions, and static allows digitized data and information to be easily stored, transferred, manipulated, and displayed, thus reducing paper clutter and improving efficiency. Digitization makes physical products programmable, addressable, sensible, communicable, memorable, traceable, and associable (Yoo 2010). Traditional physical products embedded with digital technologies, such as cameras (Tripsas 2009), phones (Ghazawneh and Henfridsson 2013), magazines (Nylén et al. 2014), and automobiles (Svahn et al. 2017), can provide a much wider range of functionality than non-digital products (Holmström 2018). The essence/essential meaning of digitization is presented in Fig. 3.

Based on the concept goodness assessment rating scale, digitization's concept goodness is discussed as follows:

Familiarity: Digitization is rooted in the modern use of the verb "digitize" and refers to "the action or process of digitizing, i.e., the conversion of analog to digital forms." If "digitization" as a whole word is not always very familiar for common people, the root "digit" and the suffix "-ization" are separately familiar. Such a level of familiarity here is enough to grasp the "conversion" nature of the term easily. However, in English, constructing a noun out of a verb by adding an "-ization" generates a double meaning (Taylor 2000). The new term will denote either the process described by the original verb or the end-state that results from the culmination of such a process (Buller and Gamble 2002). Therefore, common people can

[1] Note that data and information are used as synonyms in these definitions.

Table 1 Digitization's defining attributes and frequency

Concepts	Digitization												
Defining attributes	Negroponte (1995)	Yoo et al. (2010)	Katz and Koutroumpis (2013)	OED (2014)	Brennen and Kreiss (2016)	Legner et al. (2017)	Gölzer and Fritzsche (2017)	Schallmo and Williams (2018)	Bloomberg (2018)	Verhoef et al. (2019)	Gartner's IT glossary, n.d	Attributes frequency	Attributes repetition
Analog	✔	✔	✔	✔	✔	✔		✔	✔	✔	✔	0.37	10
Digital form/bits	✔	✔	✔	✔	✔	✔	✔		✔	✔	✔	0.37	10
Process	✔		✔	✔	✔	✔		✔	✔		✔	0.30	8
Data/information	✔	✔	✔	✔	✔		✔		✔	✔		0.30	8
Conversion	✔		✔	✔	✔	✔				✔		0.22	6
Encoding		✔					✔		✔			0.11	3
Technical	✔					✔						0.07	2
Action				✔						✔		0.07	2
Transmit									✔			0.04	1
Change											✔	0.04	1
Digitize				✔								0.04	1
Physical artifacts								✔				0.04	1
Store									✔			0.04	1
Social			✔									0.04	1
Transformation			✔									0.04	1
Techno-economic environment			✔									0.04	1

(continued)

Table 1 (continued)

Concepts	Digitization												
Defining attributes	Negroponte (1995)	Yoo et al. (2010)	Katz and Koutroumpis (2013)	OED (2014)	Brennen and Kreiss (2016)	Legner et al. (2017)	Gölzer and Fritzsche (2017)	Schallmo and Williams (2018)	Bloomberg (2018)	Verhoef et al. (2019)	Gartner's IT glossary, n.d	Attributes frequency	Attributes repetition
Socio-institutional operation			✔									0.04	1
Digital communications			✔									0.04	1
Digital application			✔									0.04	1
Signals					✔							0.04	1
Material					✔							0.04	1
Implementing								✔				0.04	1
Business processes								✔				0.04	1
Acquire knowledge								✔				0.04	1
Create new value								✔				0.04	1
Stakeholders								✔				0.04	1
Computers									✔			0.04	1

(*Source* Own illustration)
Note Attributes frequency equals the number of attributes repetition divided by the total number of defining attributes identified (27)

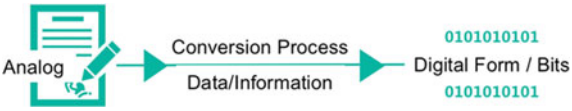

Fig. 3 The concept of digitization (*Source* Own illustration)

interpret the combination of "digit" and "-ization" in three different ways: process, result, or both. The multiplicity of possible interpretations decreases the accuracy of describing the phenomenon.

Resonance: Digitization first resonates with "digit," "digital," and "digitize." The cognitive click between "digitization" and "digital" is relevant and increases the level of the catchiness of the label/term. However, the connection between the label/term and its formal meaning is not that obvious. There is clearly a rhyming scheme in the label/term, which also increases its catchiness.

Parsimony: 5 core and 3 peripheral attributes are recurrently applied to define digitization. The number of attributes at the core meets the parsimony criteria as expressed by Gerring (1999): "[no more than] a half-dozen attributes" (p. 371).

Coherence: Digitization has a high level of internal coherence. The 5 core defining attributes (e.g., analog, digital form/bits, process, data/information, conversion) convey the essential meaning of a conversion process from analog data/information to digital form/bits. Taking the peripheral (e.g., encoding, technical, action) into consideration, the essential meaning of the action "digitize" is further strengthened. They depict a technical process of "encoding [analog] into zeroes and ones so that computers can store, process, and transmit such information" (Bloomberg 2018). The instances and attributes used to define this concept are internally consistent and logically related (see Fig. 4). To achieve a more precise elaboration, we differentiate data and information from a knowledge management perspective. Data refers to the facts and statistics collected together for reference or analysis, whereas information to "any non-random pattern or set of patterns" (Bennet et al. 2015) conveyed or represented.

Differentiation: The main challenge of defining digitization is to establish clear borders within a field of similar terms (e.g., digitalization, digital transformation). However, based on the defining attributes' analysis, this concept's definitional borders are relatively clear in the technical sense as demonstrated in coherence, thus allowing a good operationalizability.

Depth: The clear boards of digitization in the technical sense, on the other side, lower the level of its depth to cover the number of properties shared by this object/

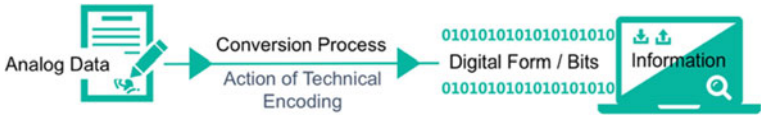

Fig. 4 The visual presentation of reconceptualized digitization internal coherence (*Source* Own illustration). *Note* Attributes "Action of Technical Encoding" are peripheral defining attributes

phenomena in its extension. In other words, poor ability of bundling characteristics. However, according to the definitions in Appendix 2, digitization is not a residual concept (i.e., define a concept by what it isn't).

Theoretical utility: Digitization was first used jointly with computers, then extended from the technical process to its impact on the development of digital technologies and their implication. It is not theory-driven since its concept inception comes from a technology implication perspective, which limited this concept's theoretical utility from its position within a narrower array of terms. Especially in computer science, digitization is used to describe the technical process of converting numerical or other information represented in a form suitable for processing by computers. However, with the unclear conceptual definitions (mixing the process and result) in the early years, this concept was used to mobilize the meanings of its related terms as they share the same roots. Simply using them interchangeably without a solid theorization process may increase this concept's theoretical utility but destroy other criteria (e.g., coherence, differentiation) and formulation of theories.

Semantic field utility: Digitization has a relatively high semantic field utility as it does not destroy these words used to define it. Digitizing the analog data does not change the understanding of converting or encoding them into digits (0 s and 1 s). None of these neighboring terms are hurt while conceptualizing digitization. By contrast, it establishes a very good relationship with them and increases their utility in the semantic field.

In short, several conclusions emerge from this evaluation: the concept of digitization performs quite well on the parameter of the term (i.e., familiarity, resonance, field utility) and intension (i.e., parsimony, coherence), and moderately on the parameter of extension (i.e., depth, differentiation, theoretical utility) concerning a lower score of theoretical utility. Digitization meets the criteria of depth and differentiation well in the technical sense. Figure 5 presents the overall result of our assessment of the term digitization on the eight criteria with the help of Gerring's framework (as shown in Fig. 2).

5.2 Digitalization and Digital Transformation

While digitization appears to be a distinct concept that refers to the technical process of converting analog data into digital formats, defining attributes of digitalization and digital transformation overlap. Therefore, a systematic analysis of digital transformation's concept formation and conceptualization evolution constitutes a prerequisite for further theorization and modelization. To achieve better readability, the authors decided to present these two concepts together to show the commonality and difference.

Gong and Ribiere (2021) reviewed 134 digital transformation definitions to provide insights into six core defining primitives of this concept. They found that the challenge and need to develop a sustainable nomenclature of digital-related terms

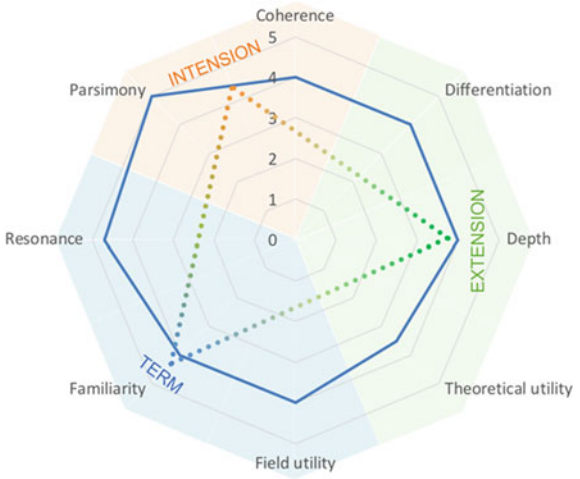

Fig. 5 The concept assessment result of "digitization" (*Source* Own illustration)

and concepts is an urgent and important problem to tackle, especially the difference between digitalization and digital transformation.

This chapter further discusses these two distinct, yet interrelated concepts through a diachronic analysis of their definition attributes based on empirical evidence. Thus, a search query for empirical papers studying digitalization and digital transformation was performed in the EBSCO database, and full-text papers were downloaded and screened for their eligibility. Thirty-six definitions were extracted based on empirical evidence, including 24 definitions of digital transformation and 12 definitions of digitalization. The defining attributes and their frequency for each term are listed in Appendix 3 to clearly show their similarities and differences.

In total, there are 41 defining attributes for digital transformation and 30 for digitalization, which indicates a high level of discrepancy among the available definitions and the issue of conceptual stretching in these definitions. Regarding the etymological and historical issues discussed in Sects. 2 and 3, it is not surprising that around 36% (15 out of 41) of digital transformation's defining attributes overlap with digitalization. Taking a closer look at these attributes, the internal coherence and external differentiation are debatable. No single definition that encompasses all or most of the core and peripheral defining attributes also supports this view. Such diversity of attributes either indicates the multiplicity of meanings attached to one concept or suggests there should be two or more concepts to better discriminate the meanings based on logical internal coherence and external differentiation. The choice made here will also affect the theory-building associated with these terms in the long run.

Having a clear boundary for each concept will determine what reality is effectively attached to a particular concept and benefit the empirical research to obtain consistent and comparable results. To achieve such aims, a deep analysis of all these defining attributes (of the concepts *digitalization* and *digital transformation*) in the context of the papers from which the definitions were extracted is needed. The same methodology used to analyze the concept *digitization* was applied again to analyze the core

and peripheral attributes for assessing the concepts of *digitalization* and *digital transformation* based on Gerring's (1999) framework. However, we decided not to present our analysis in all its details here to avoid content repetition and overextending the scope of this chapter.

Digitalization. Looking at all the defining attributes of digitalization, the following points can be drawn:

- Firstly, digitalization refers to the change process of adopting and using digital technologies, whether these changes occur in individuals' connection and their behaviors (Gimpel and Röglinger 2015), or the manifold socio-technical changes in broader individual, organizational, and societal contexts (Legner et al. 2017). This variety of change in the context of digitalization indicates a contextual hierarchy in these definitions.
- Secondly, the outcome of digitalization is more focused on describing the consequences that implementing digital technologies may have on offerings (i.e., products and services) and the quality of the organization's relationships with others (e.g., increased simplicity, efficiency, speed, competitiveness, etc.). It focuses on the change of existing socio-technical structures that were previously mediated by non-digital artifacts (Thorseng and Grisot 2017) and the potential changes in the processes beyond the mere digitizing of existing processes, forms, and work products (Parviainen et al. 2017a, b). That is, it is beyond the technical process of digitization. In contrast, digitalization is the main driver that affects the business environment and inter-functional coordination in particular (Ruiz-Alba et al. 2019) to integrate the functional silos. It is a means to fulfill customers' needs more effectively (Rachinger et al. 2019) and makes businesses act rapidly in a short time frame (Sehlin et al. 2019). It has accelerated the shift from product-based to service-based businesses, affecting fundamentally how firms compete for and transact with customers (Hänninen et al. 2018). It changes the relationships into ones that are mediated by digitized artifacts and relationships with newly embedded digital capabilities (Thorseng and Grisot 2017).
- Thirdly, digitalization may be a source of an organization's competitive advantage through increased efficiency. It improves the organization's effectiveness and influences its internal structures by reinforcing interdisciplinary collaboration (Rachinger et al. 2019).

Figure 6 presents the identified defining attributes of digitalization. It reveals that there are several dimensions included in this concept, some of which overlap with digital transformation. This overlap is rooted in the etymological confusion as discussed in Sects. 2 and 3, leading to an unclear border with digital transformation. A further explanation to realign these dimensions is needed to increase its internal coherence and external differentiation to understand this concept better.

The concept of digitalization is woefully debatable. In the case of picking out one phenomenon among other phenomena, this concept generates confusion by linking its neighboring concepts with their overlapping attributes in reference to various objects/phenomena. That is, an undifferentiable conceptual definition may contribute to digitalization's familiarity, resonance, and depth; however, it largely diminishes its

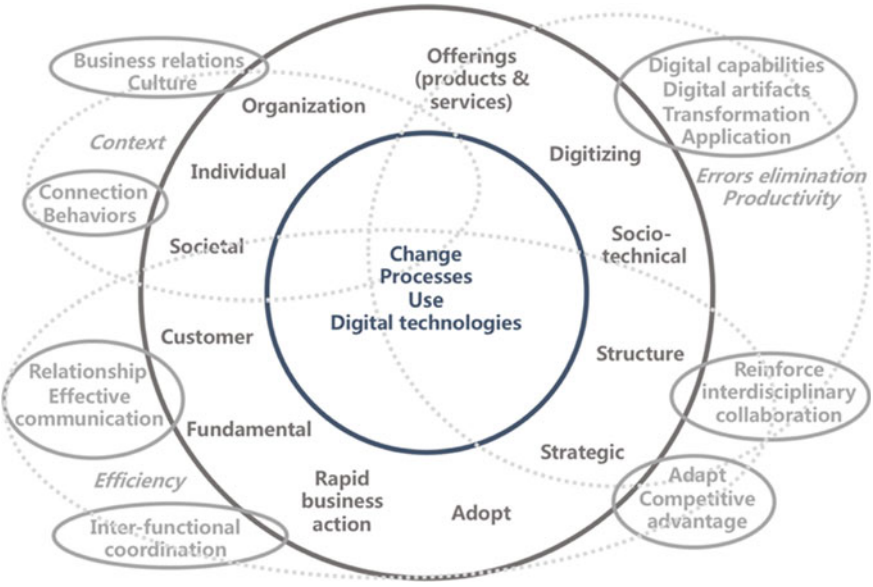

Fig. 6 The core and peripheral defining attributes of digitalization (*Source* Own illustration). *Note* The defining attributes away from the bullseye in the small circles are the outsiders (low frequency) compared to the core defining attributes in the inner ring and peripheral in the outer ring

level of differentiation and blurring its boundaries from other neighboring concepts. Without a clear boundary specifying digitalization's nature, such confusion will continuously damage the semantic field utility and connect phenomena whose shared properties are not related in some manner. Therefore, a reconceptualization with a high level of coherence and differentiation is needed for this concept to perform better in extension and intension.

Digital Transformation. In a different vein, looking at the defining attributes of digital transformation (DT), the scope and the expected outcome of digital transformation are different from that of digitalization:

- Firstly, digital transformation refers to a transformation (i.e., fundamental change) process of using digital technologies rather than a non-fundamental change process. Liu et al. (2011) defined digital transformation as "an organizational transformation that integrates digital technologies and business processes in a digital economy" (p. 1730) based on their qualitative case study of CBC Bank's global e-banking project. Digital technologies are used to transform the customer value proposition and organizing operations to create new business models (Berman 2012). It changes a business model in how the organization creates value for its customers (i.e., customer value proposition) and how it captures that value (i.e., how it makes money) (Iansiti and Lakhani 2014). Kane et al. (2015) confirmed digital transformation as an organizational transformation, where digital technologies transform the business models and processes,

based on their survey of more than 4,800 business executives, managers, and analysts in 129 countries and 27 industries, as well as interviews with business executives and technology vendors. Such transformation of business activities, processes, models, competencies, operational routines, and organizational capabilities to fully leverage the changes and opportunities brought by digital technologies is profound and fundamental in nature (Demirkan et al. 2016; Li et al. 2018). It encompasses the networking of actors such as businesses and customers across all value chain segments and applying digital technologies (Schallmo et al. 2017). Hence, these aforementioned attributes resonate with the emerging notion of business model innovation, which has received massive practical (Pohle and Chapman 2006) and theoretical (Schneider and Spieth 2013, 2014; Zott et al. 2011) interest in recent years. Its broad definition as "the implementation of a business model that is new to the firm" (Björkdahl and Holmén 2013, p. 214), and its main dimensions of value creation, value proposition, and value capture (Baden-Fuller and Haefliger 2013; Clauss 2017; Johnson et al. 2008; Massa and Tucci 2014; Morris et al. 2005; Zott and Amit 2013) fit the expected end results where digital transformation is heading to at the strategic level.

- Secondly, the end result of digital transformation is a significant *transformation* (i.e., a redefinition of mission and purpose to reflect a new direction), rather than a simple *realignment* (i.e., a change to the way of doing things that do not involve a fundamental reappraisal of the central assumptions and beliefs within the organization) from a change management perspective (Balogun et al. 2015). Digital transformation generates radical improvement (Westerman et al. 2011). It is a holistic effort to revise core processes and services, which results in a complete revision of the existing and the creation of new digital products and services (Mergel et al. 2019). Digital transformation goes beyond just technological shift (Kane et al. 2015); it also involves the process of strategic renewal and dynamic capabilities development of an organization (Warner and Wäger 2019) to address the opportunities and risks that originate from digital technologies (Singh and Hess 2017). It affects employees' operational work routines (Chen et al. 2014) at the operational level, and also managerial processes (Iansiti and Lakhani 2014) and human relations (Mićić 2017) at the managerial level. Redefining the organization's value propositions may be shaped by customer interaction and collaboration (Berman 2012) and customer engagement (Schuchmann and Seufert 2015). Digital transformation can influence organizational culture and capabilities (Li et al. 2018; Tan et al. 2015) and "lead to highly dynamic markets, pressuring employees to continuously adapt to new situations and increasing the need for agility and lifelong learning" (Schwarzmüller et al. 2018, p. 126). While top executives set and drive the digital agenda, it's crucial that they also put a focus on employees and talent engagement to achieve digital maturity (Kane et al. 2015).
- Thirdly, while 11 definitions out of 24 studies explicitly acknowledge organizations as the entity (i.e., the unit of analysis affected by digital transformation), few studies also include industry and society as entities. Digital transformation is the integration of digital technologies into business, resulting in fundamental changes in the way the world does business and communicates (Mićić 2017).

Digital technologies are rapidly transforming the fundamental nature of a broad range of organizations and revitalizing their digital business models across industries (Demirkan et al. 2016). Such a holistic form of business transformation is accompanied by fundamental economic and technological changes at the organizational and industry-level (Chanias et al. 2019) and unfolds their impact across society in a strategic and prioritized way (Demirkan et al. 2016). This indicates a multiplicity of the entity affected by digital transformation.

- Lastly, using "digital economy" and "digital maturity" to define digital transformation raises the issue of conceptual stretching, which refers to the distortion that occurs when a concept does not fit the new cases (Collier and Mahon 1993; Sartori 1970). These two terms themselves remain unspecified in the literature. Utilizing them to broaden digital transformation's connotations can stretch digital transformation to "cover instances that lie quite a bit outside their normal range of use" (Gerring 1999, p. 360).

Figure 7 shows the identified defining attributes of digital transformation.

In short, several conclusions emerge from this evaluation. It is noteworthy that the concept of DT performs quite well on several criteria: it is familiar and resonant and seems to be sufficiently parsimonious and highly theoretically useful. Therefore, as noted above, it is little wonder that the concept gained popularity so quickly, which has put it at a risk of turning into a buzzword. However, with a reconceptualization that better connects the essence of defining attributes, the overall concept assessment results improve. The concept DT performs quite well in its term, extension, and

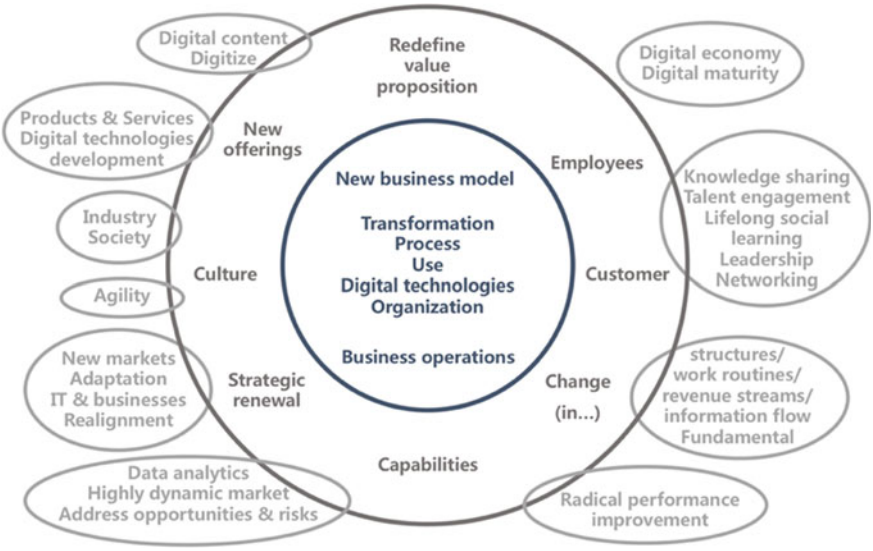

Fig. 7 The core and peripheral defining attributes of digital transformation (*Source* Own illustration). *Note* The defining attributes away from the bullseye in the small circles are the outsiders (low frequency) compared to the core defining attributes in the inner ring and peripheral in the outer ring

intension: high resonance and theoretical utility; good depth, familiarity, coherence, and differentiation; moderate parsimony, and field utility to some extent.

5.3 Synthesis

Following all the discussion in this section, there are some overlaps of digitalization and digital transformation: both terms acknowledge the change process enabled by digital technologies. Yet, they are emphasizing the different scope and end results of this change process. Indeed, both digitalization with the suffix "-ization" and digital transformation using the term "transformation" indicate that the deep nature of these concepts is a process, more specifically, a change process. However, in general, the existing literature is not sufficient to differentiate digitalization from digital transformation.

Only considering core defining attributes, the critical attribute to distinguish these two concepts is "change" (digitalization) versus "transformation" (digital transformation). Such difference in terms of the scope of the change to further differentiate these two concepts is evident in the domain of change management but may not be obvious in common language. From a change management perspective, this core defining attribute for each concept already indicates the different nature of the process enabled by digital technologies and the expected end-result they may achieve. Regarding the scope of change, digitalization is an incremental or continuous change that involves installing digital technologies needed to keep an organization on its chosen path with improved efficiency. This change may not necessarily be small, even involve significant commitments of resources, time, people, and money. However, it has not fundamentally altered the organization's core (i.e., the organization's central assumptions and beliefs), such as the structures, missions, visions, cultures, etc. On the contrary, digital transformation encompasses a fundamental shift in the organization's business model, touching all structural, cultural, and procedural aspects. It is an all-encompassing metamorphosis (transformation) of an entity (organization). This entity affected by such fundamental change is included in digital transformation's core defining attributes, but not mentioned in digitalization's definitional core.

Extending to digitalization's peripheral attributes, there is a contextual hierarchy of the entities affected by this change (i.e., individual, organizational, and societal). A similar hierarchy can be found in digital transformation's defining attributes (i.e., organizational, industrial, societal). Moreover, if the digital transformation definitions were extracted from both conceptual and empirical papers, the entities affected by digital transformation would encompass an organization, a business network, an industry, or society (Gong and Ribiere 2021). Hence, this hierarchical perspective is one dimension that needs further research.

If we only consider organizations as the entity, we propose that digital transformation focuses on transforming the organizations' business operations to create new business models. In contrast, digitalization focuses on the installation of digital technologies, so that they can be used to achieve economic-driven outcomes (e.g.,

improve efficiency and productivity, or error elimination). It is a means to help the organization reinforce its existing value proposition efficiently and effectively, i.e., a change to the way of doing things with the deployment of digital technologies in place. It does not involve a fundamental reappraisal of the organization's central assumptions or a paradigm shift of its organizational identity or business model. Therefore, based on our comprehensive analysis, we conclude that digital transformation is not equivalent to digitalization, and recommend the two concepts to be kept distinct at the conceptual level.

6 Discussion

The growing penetration of digital technologies in the market with the associated changes inevitably drive organizations to rethink their options to digitally transform themselves.

To better understand the evolution of digital transformation, this chapter discussed the confusion around the DT concept and its related concepts (i.e., digitization, digitalization) following a systematic methodological approach. Firstly, we presented the etymology of the three concepts, leading to a discussion of the main etymological reasons behind the confusion. Secondly, we discussed the historical evolution of these concepts, thereby revealing their inconsistent use in the existing literature; here, we also offered a synthesis of what realities/phenomena these terms are associated with. Thirdly, we introduced the concept formation and assessment methodology of Gerring (1999) to lay the theoretical foundation of how concepts can be analyzed and assessed. Finally, we collected existing definitions of digitization, digitalization, and digital transformation, and then systematized these based on a defining attributes analysis. Next, we performed and presented a detailed example of how digitization's historical defining attributes were analyzed and assessed based on Gerring's eight criteria. The results of the same analysis for digitalization and digital transformation were presented as well. To our best understanding, these three concepts are interrelated, yet they should be kept distinct at the conceptual level to describe various strategizing and organizing activities in practice and different implications at multiple levels of analysis in research. Based on our comprehensive analysis, we propose differentiating the three concepts as follows:

- ***Digitization*** is the technical process of converting analog into digital formats.
- ***Digitalization*** is the change process of installing digital technologies to reinforce the organization's existing value proposition.
- ***Digital transformation*** is a fundamental change process of an organization enabled by exploring the use of digital technologies to redefine its business models.

On the academic front, this chapter offers a solution to solve the definitional and theoretical inconsistency in the extant literature regarding digital transformation and its related terms. It potentially contributes to developing a consistent stream of

research with differentiable concepts for theory-building and compatible research findings to guide business practices.

This chapter also reveals the reality/phenomenon of these concepts on the practical front, providing a clearer guideline for practitioners to develop differentiable strategic plans for organizations to "go digital." Leaders, executives, and employees can use these concepts consistently while referring to specific strategizing and organizing activities for different entities (individual, team, organization, industry, and society). Having a clearer understanding of these phenomena' essence helps to claim authority and job responsibility for digital-related projects at the organizational level and makes it easier to benchmark one's performance against other organizations and industries on digital transformation metrics and best practices at the industrial level.

In conclusion, the evolution of digital transformation offers an opportunity of renewal for many organizations all over the world. Outlining the etymological and historical reasons behind the confusion around digital transformation and analyzing the existing literature, we proposed a solution to differentiate these concepts for the goodness of both academic and practitioner communities. We hope that our work will assuage the "fuzziness" issue associated with these concepts and inspire academics and practitioners to use these terms more carefully, discriminatively, and consistently.

Disclaimer Selected portions of this chapter have previously appeared in the author's work and are used with permission.

Gong, C., & Ribiere, V. (2023). A historical outline of digital transformation. In *Digital Transformation in Healthcare in Post-Covid-19 Times* (pp. 3–25). Academic Press, Elsevier.

Gong, C., Parisot, X., Reis, D. (2023). Die Evolution der Digitalen Transformation. In: Schallmo, D.R.A., Lang, K., Werani, T., Krumay, B. (eds) Digitalisierung. Schwerpunkt Business Model Innovation. Springer Gabler, Wiesbaden.

Appendix 1: The Etymologies of the Terms Digitization, Digitalization, Transformation, and Digital Transformation

Terms	Etymologies
Digitization	The origin of "digitization" is rooted in the modern use of the verb "digitize" (digit + -ize), which is used in reference to computer programming, meaning "the process of converting something into the form of especially binary digits" from 1954 (Merriam-Webster n.d)
Digitalization	The origin of "digitalization" is rooted in the adjective "digital" from ancient Latin *digitus* and modern Latin *digitalis*. It has been used in reference to "using numerical digits" from 1938, especially "of computers which run on data in the form of digits (opposed to analog)" after c. 1945; and "recording or broadcasting" from 1960 ("Online Etymology Dictionary" n.d)

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Terms	Etymologies
Transformation	The origin of "transformation" is rooted in Old French *transformation* (14c.) and directly from the Latin Church *transformation* (nominative *transformation*) "change of shape" (transitive), noun of action from past participle stem of *transformare* "change in shape, metamorphose," from *trans* "across, beyond" + *formare* "to form." Intransitive sense "undergo a change of form" is from the 1590s ("Online Etymology Dictionary" n.d)
Digital transformation	This concept consists of two terms, "digital" and "transformation." The denomination strategy of compounding two words together combines the halo effect of these two words' meaning in the common language and creates a new meaning in the scientific language (Dumez 2011). Since no single seminal definition specifies the original scientific meaning of digital transformation, the confusion existing between scholar's divergent definitions is added to the one connected to the combination of halo effects in the common language. That is, while the meaning of "transformation" and its established usage within practitioners' everyday language and academic' specialized language are clear in the common language, the meaning of the shared root "digital" is generating confusion for the concept digital transformation. A screening by Mertens et al. (2017) produced a list of over 2,500 different terms associated with "digital" in recent scientific literature and financial press. This list includes almost all facets of modern social and economic life. Such finding of diversified common meanings of "digital" also supports the view that "digital" is the troublemaker that causes the combined term "digital transformation" unclear

Appendix 2: The Definitions of Digitization

Authors	Definitions of digitization
Negroponte (1995)	"The conversion of analog to digital information and processes in a technical sense" (p. 15)
Yoo, Henfridsson, and Lyytinen (2010)	"The encoding of analog information into digital format" (p. 725)
Katz and Koutroumpis (2013)	"Digitization, per se is the process of converting analog information to a digital format. Digitization, as a social process, refers to the transformation of the techno-economic environment and socio-institutional operations through digital communications and applications" (p. 314)
OED (2014)	"The action or process of digitizing; the conversion of analog data (esp. in later use images, video, and text) into digital form"
Brennen and Kreiss (2016)	"The material process of converting analog streams of information into digital bits" (p. 1)
Legner et al. (2017)	"The technical process of converting analog signals into a digital form, and ultimately into binary digits" (p. 301)

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Authors	Definitions of digitization
Gölzer and Fritzsche (2017)	"The encoding of data in digital formats" (p. 1334)
Schallmo and Williams (2018)	"Digitally enabling analog or physical artifacts for the purpose of implementing into said artifacts into business processes with the ultimate aim of acquiring newly formed knowledge and creating new value for the stakeholders" (p. 5)
Bloomberg (2018)	"Taking analog information and encoding it into zeroes and ones so that computers can store, process, and transmit such information"
Verhoef et al. (2019)	"The action to convert analog information into digital information" (p. 891)
Gartner's IT Glossary (n.d.)	"The process of changing from analog to digital form. It takes an analog process and changes it to a digital form without any different-in-kind changes to the process itself"

Appendix 3: Digital Transformation and Digitalization's Defining Attributes and Frequency

Research Types	Qualitative study										Qual. case study			Case study			Quan.	QQ	Examples			Concepts			Research Types	Qualitative				Qualitative cs					Workshop		
Authors	Westerman et al., 2011	Hess et al., 2016	Singh & Hess, 2017	Li et al., 2018	Gimpel et al., 2018	Schwarzmüller et al., 2018	Warner & Wäger, 2019	Mergel et al., 2019	Liu et al., 2011	Schuchmann & Seufert, 2015	Pagani & Pardo, 2017	Chanias et al., 2019	Ivanović et al., 2019	Iansiti & Lakhani, 2014	Schallmo et al., 2017	Hellig et al., 2017	Ali-Ruithe et al., 2018	Fitzgerald et al., 2014	Sousa & Rocha, 2019	Kane et al., 2015	Berman, 2012	Demirkan et al., 2016	Matzl, 2017	Morosi, 2018	Digital transformation		Digitalization		Authors	Gimpel & Röglinger, 2015	Mergel et al., 2019	Sjödin et al., 2019	Ruiz-Alba et al., 2019	Richtner et al., 2019	Pagani & Pardo, 2017	Thordsen & Gelsol, 2017	Parviainen et al., 2017	Hänninen et al., 2018	Legner et al., 2017	Reid et al., 2017	Bra & Lorentz, 2019
# Defining Attributes	4	7	5	13	7	5	8	6	5	9	8	4	5	8	6	7	5	5	5	7	8	10	11	5	Freq	24	Freq	12	Defining Attributes	7	9	4	4	6	8	5	6	4	7	3	2
1 Processes		✓		✓				✓	✓		✓		✓		✓	✓	✓		✓	✓		✓	✓	✓	0.58	14	0.58	7	Change	✓									✓	✓	✓
2 Digital technologies	✓	✓	✓	✓	✓		✓	✓	✓		✓		✓		✓	✓		✓	✓	✓	✓	✓	✓	✓	0.58	14	0.42	5	Digital technologies	✓					✓				✓	✓	✓
3 Organization	✓	✓	✓	✓	✓				✓						✓	✓	✓		✓	✓	✓				0.48	11	0.33	4	Use	✓									✓	✓	✓
4 Transformation				✓				✓	✓			✓				✓			✓	✓	✓			0.38	9	0.33	4	Processes		✓							✓		✓	✓
5 Business operations											✓			✓			✓	✓			✓	✓	✓	0.33	8			Frequency	3	2	1	1	1	1	2	1	3	2	3	2
6 Use	✓			✓			✓							✓	✓	✓		✓			✓		✓	0.33	8	0.17	2	Offerings					✓				✓			
7 New business model		✓			✓		✓		✓					✓	✓			✓				✓		0.33	8	0.17	2	Organization						✓				✓		
Frequency	3	4	2	4	3		4	3	4	1	2	2	1	3	4	5	2	4	2	3	5	5	3	4			0.17	2	Rapid business action			✓	✓								
8 Customer							✓		✓	✓	✓							✓			✓		✓	0.29	7	0.17	2	Customer				✓						✓		
9 Change		✓		✓					✓			✓										✓	✓	0.25	6	0.17	2	Strategic			✓	✓								
10 Create new value (proposition)					✓		✓		✓		✓			✓						✓		✓		0.25	6	0.17	2	Digitizing		✓						✓				
11 Strategic renewal			✓				✓				✓					✓				✓		✓		0.21	5	0.17	2	Societal	✓									✓		
12 New offerings (products & services)	✓						✓		✓		✓				✓									0.17	4	0.17	2	Structures					✓		✓					
13 Employees						✓					✓					✓				✓				0.17	4	0.17	2	Socio-technical							✓			✓		
14 Culture					✓								✓			✓						✓		0.17	4	0.17	2	Individual	✓									✓		
15 Capabilities (development)				✓			✓							✓									✓	0.17	4	0.17	2	Fundamental								✓	✓			
Frequency	2	1	2	1	1	3	4		1	4	1	1	1	2	3	1	1		2	2	3	4					0.17	2	Adopt					✓					✓		
16 Networking/relationship/connection							✓							✓								✓		0.13	3			Frequency	2	1	2	2	3	2	2	2	3	5		
17 Radical performance improvement	✓													✓			✓							0.13	3	0.08	1	Transformation						✓						
18 Fundamental				✓								✓										✓		0.13	3	0.08	1	Culture			✓									
19 Digitize											✓			✓									✓	0.13	3	0.08	1	Adapt					✓							
20 Change in work routines				✓	✓																	✓		0.13	3	0.08	1	Digital capabilities						✓						
21 Adaptation				✓	✓	✓																		0.13	3	0.08	1	Effective					✓							
22 Realignment between IT & businesses				✓						✓												✓		0.13	3	0.08	1	Behaviors	✓											
23 Lifelong social learning					✓														✓					0.08	2	0.08	1	Interfunctional coordination				✓								
24 Digital maturity												✓								✓				0.08	2	0.08	1	Digitized artifacts						✓						
25 Digital economy									✓		✓													0.08	2	0.08	1	Competitive advantage				✓								
26 Change in structures		✓		✓																				0.08	2	0.08	1	Reinforce interdisciplinary collaboration				✓								
27 Capture value/revenue streams					✓									✓										0.08	2	0.08	1	Connection	✓											
28 Address opportunities & risks			✓																			✓		0.08	2	0.08	1	Relationship						✓						
Frequency	1	1	1	5	3	2	1		1	1	2	1	1	2	2		1		1	1		2	4	1			0.08	1	Relations					✓							
29 Talent engagement																				✓				0.04	1	0.08	1	Application						✓						
30 New markets				✓																				0.04	1			Frequency	2		1	1	5	1	4					
31 Leadership																								0.04	1															
32 Knowledge sharing																			✓					0.04	1															
33 Industry												✓												0.04	1															
34 Digital technologies development													✓											0.04	1															
35 Digital content																			✓					0.04	1															
36 Data (Analytics)														✓										0.04	1															
37 Change in information flow				✓																				0.04	1															
38 Beyond functional thinking			✓																					0.04	1															
39 Agility						✓																		0.04	1															
40 Highly dynamic market						✓																		0.04	1															
41 Society																						✓		0.04	1															
Frequency			1	2		2						1	1		1	1				2	1	1																			

Note "Qual." and "Quan." means qualitative and quantitative research, respectively. The abbreviation "QQ" means "qualitative + quantitative research," indicating a mixed-method research approach is applied in this paper. The defining attributes were grouped based on their accumulated frequency. The core defining attributes are shown in the first group (i.e., the top 7 for digital transformation and the top 4 for digitalization); the peripheral ones are in the following/second group; the rest are outsiders

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