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ORIGINAL RESEARCH

Adopting an Ecosystem Approach to Digitalization-driven Organizational Change ? Actionable Knowledge from a Collaborative Project

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Abstract
A vibrant debate has emerged on the opportunities of digitalization for 'humanizing' work versus substitution or deskilling effects. Recognizing the processes of designing digitalized organizations as crucial for predicting the outcome of digitalization on workers and labor, extant research has developed an evolutionary ecosystem socio-technical (STS) perspective aimed at designing more human organizations in light of digital transformation. In this study we build upon the STS ecosystem analytical framework by Winby and Mohrman (2018), aiming to explore how the STS design principles, as proposed by said authors, are applied in three big manufacturing companies, in light of digitalization. Data collected through qualitative techniques has been analyzed abductively. Findings provide a detailed overview of how the STS ecosystem design principles are operationalized, and shed novel light on applied design methods, such as 'agile' and 'design thinking', able to support interconnection among systems, in a never-ending and iterative process. This study extends the existing ecosystem STS organization design conceptual model by exploring 'how' we change, 'who' the change is for, while also investigating 'what' this means for the hitherto conceptualized STS work-system. Implication for management practice and ODC scholarship are also discussed.

Keywords Digitalization · Socio-technical principles · Ecosystem · Integrated Design · Multistakeholder · Agile · Design Thinking

Introduction

Digital technologies are transforming how, when, and where work gets done, as well as by whom and for whom (Bailey et al. 2019). With the potential for such changes in scope, new questions arise related to work and organizational aspects, such as coordination, learning, agility, professional roles and boundaries, skill and competences, socialization practices, and much more (Bailey et al. 2019). Most studies that focus on the interaction between

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digitalization and organizational change have mainly maintained a deterministic stance (Bodrožić and Adler 2018; Ford 2015; Zuboff 2019), arguing that digitalization could either be empowering for work and its organization, or conversely, it could dehumanize the workplace (Moore and Robinson 2016).

However, digital technologies increase the chance of bringing in symmetry among systems. Compared to the traditional business environment, digitalization provides a new organizational setting for firms, as it intensifies connections among the technical and the social systems of an organization as well as connections with external networks through the sharing and exchange of digital information (Za et al. 2014). Thereby, new work systems are being configured around a network of digital platforms into which algorithms and routines are built for coordination, artificial intelligence and machine learning, and advanced analytic capabilities (Wang et al. 2016). Hence, digital transformation is pushing integration between the social and the technical as well as integration of the firm with its ecosystem, such as suppliers and customers (Schuh et al. 2017). Thereby, many authors, among whom Hirsch-Kreinsen (2016) and Parker and Grote (2019), have seen a greater opportunity for creating symmetry between people, work, and technology systems, which is also a renewed opportunity for socio-technical joint optimization.

In such a context, the new, ecosystem perspective of the STS (Pasmore et al., 2019; Wit et al., 2019; Winby and Mohrman 2018) has emerged that breaks with its classic predecessor (Trist et al., 1981) and seeks to address the dynamic environment and the ecosystemic challenges that organizations face in light of digital transformation. Building upon this new reconceptualization of STS, which suggests that the new scope of STS design in light of digitalization should lie in continuous socio-technical and market optimization, Winby and Mohrman (2018) have reworked the three classic STS organization design principles, which now include (i) integration across the ecosystem, (ii) extension of stakeholder participation to also incorporate external stakeholders, and (iii) a continuous and iterative approach between and beyond systems of an organization. Despite the increasing number of studies focusing on the digitalization as an interplay among systems, empirical research is scant, and we still lack a clear understanding of the dynamics of a firm's ecosystemic organizational transformation in light of digitalization.

Given the importance of a socio-technical perspective to ensure that the needs of human beings and social systems are respected and brought into balance with the advantages offered by digital technology (Pasmore et al., 2019), and given the limited understanding on the dynamics of the ecosystem STS approach (see also Literature Review from Reis et al. 2018), our purpose in this paper is to explore 'how' the ecosystem STS principles (as developed by Winby and Mohrman 2018) have been operationalized during organizational design in light of digitalization.

Drawing on evidence collected from an abductive, collaborative case study research work, we show how the ecosystemic STS organizational design approach ensures balanced optimization of the social and the technical within the ecosystem where the organization operates, while predicating a 'continuous experimentation' perspective. Design methodologies adopted by organizations encompass such perspective, which constantly generates solutions and routines and binds users, suppliers, and customers to the work system. This study offers a number of implications for management research and practice.

Literature Review

This section presents an overview of the changing relationships inside an organization and in the ecosystem, in light of digital transformation. We start by exploring the 'connecting' features of digital technologies that also serve as the connective tissue in the firm's ecosystem. A brief portrayal is presented of the state-of-the-art literature that explores the relationship between introduction of digital technologies and the challenges this portends to the organization of work, and related shortcomings are also presented. Thereafter we illustrate how today's digital socio-technical design is able to encompass the changing context, while aiming at joint optimization at the ecosystem level. In the last subsection, we identify the gaps that lead us to the definition of our research objective.

How Digital Technology are Expanding the work System Boundaries, Spilling over into the Ecosystem

As digital technologies have engendered significant outcomes for work and organization, many authors claim that the evolution of social systems is not keeping pace with the exponential advance of technology. Indeed, in the literature strand that studies the relationship between digital transformation and organization of work, a deterministic stance prevails regarding the opportunities (mainly related to organizational performance optimization) and the risks (mainly related to the possible reduction in operators' work quality) that come along with the reorganization process, assuming that organizational design is but an adaptation to digital affordances/constraints.

However, the 'connective' aspect of digital technologies offers the potential to challenge the above techno-centric stance. Indeed, digital technologies, while aiming to encompass the whole product's lifecycle (Wang et al. 2016), are pushing for a higher level of interconnection among systems within an organization (Schuh et al. 2017). Even more so, digital platforms are pushing and supporting horizontal integration (Frank et al., 2020), in order to ensure exchange of real-time information on production orders with suppliers and distribution centers (Pfohl et al. 2017), and to reach customers by tracking product delivery (Pfohl et al. 2017). Hence, firms are operating in an environmental context, whereby a "community of living organisms stays in conjunction with the non-living components". Such a mapping of a firm's business environment is referred to as a firm's ecosystem, "where the 'eco' part of the word is assumed to be related to the environment and 'system' implies the function as a collection of related parts that function as a unit" (Smith and Smith 2015). In the digitalization context, the general definition of ecosystems is, actually applied to the digital ecosystem (Sussan and Acs 2017) which requires the firm to adopt new tools and systems in operations and management (Autio, 2017), thus adding to the complexity of organizational change, and is argued to be key to firm growth and competitiveness in the long run (Franke et al. 2020).

Given such considerations, it becomes important for a firm to achieve ongoing adaptation among its systems and with its ecosystem, a concept capable of representing the exchange and connection between different actors and factors (Audretch et al., 2019). Hence, the firm's process of adaptation – to its digital transformation – involves re-alignment of its business model, social and technical activities and practices with the new context.

An Evolutionary Ecosystem STS Perspective to Bring Symmetry Among People, Technology, and the Environment

In the quest for co-optimization between the social and the technical systems and their re-alignment with the ecosystem, contemporary STS researchers (Pasmore et al. 2018; Winby and Mohrman 2018; etc.) have realized an opportunity to revisit the classic STS literature (see Trist et al., 1981). Pasmore et al. (2019) used a laboratory digital socio-technical setting in order to explore the dimensions of digital STS change management. The authors concluded that, in contrast to traditional STS design, where changes are made to bring the social system into better alignment with a fixed technical system, in the digital STS organization the social and the technical systems are co-evolving in service of better performance and in accordance with the expectations of the environment. In the same direction, Winby and Mohrman also analyzed the boundaryless world in which organizations operate nowadays. In their study, they present a re-conceptualization of the three classic STS design principles (see Trist et al., 1981) which now also encompass the ecosystem elements and actors. In fact, the first STS design principle 'Joint optimization of the social and the technical' has been reworked to reflect 'Integration of field of action across the ecosystem'. The 'expanded unit of analysis' approach is carried over to the second STS principle 'Broad participation of stakeholders'. This principle is extended to also take the interests of external stakeholders into account – and not only those of managers and employees. The third classic STS principle 'Continuous approach to design' has also been extended to advocate a design approach based upon short iterative continuous experimentation cycles leading to continual adjustments at the ecosystem level. Such a dynamic organizational design perspective aims at delivering greater value to stakeholders by changing the relationships in the ecosystem and expanding participation in the designing of digital platforms and work systems that should acknowledge high levels of interdependence of roles and outcomes. The unit of analysis for work system and organization design should therefore be the entire ecosystem.

Research Objective and Positioning of the Current Study

Conceived as a means of enhancing productivity while simultaneously providing more meaningful work, socio-technical thinking has gained ground with the advantages offered by digital technology (Pasmore et al., 2019).

In order to adequately address the new reality of an organization whereby the transition to digital platforms that coordinate, integrate, process information, and learn across many actors in an ecosystem is well underway, Winby and Mohrman have proposed an ecosystem STS design framework that enables the design of an equitable organization characterized by the values of development and meaningful participation. However, extant literature still lacks an understanding of how to actually build an ecosystem STS organization in light of digital transformation. Therefore, this study explores what an organization adopting an ecosystem STS approach in light of digital transformation actually does, and how it does it. Our research objective is to better understand 'how' the ecosystem STS principles (as developed by Winby and Mohrman 2018) can be operationalized during organizational design in light of digitalization. Given the scope of this research, we expect to extend existing ecosystem STS framework with the dynamics of the process and to also bring forward actionable research (see call for actionable research from Schwarz and Vakola 2021), in particular applied ODC research.

Methodology

The trigger for this study was a set of conversations that the authors had with the managers of the observed companies while these were undergoing major organizational changes in light of digital transformation. On such basis the authors made the decision to activate a research project aimed at (broadly) exploring how to systemically approach organizational re-designing in light of digitalization. A research team was established including both researchers and practitioners, namely this study's authors and professionals (program/project leaders) from the studied organizations, which were all undergoing a change process. Concretely, the researcher-practitioner research team had several meetings, both during and after the implementation of new technology; said meetings were aimed to (i) explore how the companies assessed and approached the organizational change; (ii) select the sample and coordinate data collection; and (iii) collectively interpret the results and develop practical implications, which in turn led to several interventions from the companies' management.

Qualitative case Study Research

Since digital transformation is the process whereby a firm adapts to the new context, with changes involving many variables that cannot be tested with pre-set hypotheses, and also in view of the aforesaid lack of knowledge on the 'how' of the ecosystem STS organizational design process, the researchers decided to adopt a qualitative approach (Gephardt 2004; Yin 2002). Moreover, the epistemic object of this study, related to the firm's organizational practices and routines, required not only an in-depth investigation through qualitative investigation (King et al., 1994), but also a real-life context relevant and important to the analysis. Such a context called for a case study approach, which would offer the researchers the advantage of a more contextualized perspective and simultaneously give them the opportunity to analyze and synthesize similarities and differences and extract patterns across cases (Eisenhardt and Graebner 2007; Ragin and Amoroso 2011).

Case Study Description

The researchers selected three case studies. The selection was made in line with our STS theoretical lenses, on the premise of their being similar to other cases of STS design in light of digitalization. All three cases were identified in the context of a bigger research project investigating the dissemination of joint and participative socio-technical design methods during the adoption of Industry 4.0 technologies. The researchers were familiar with the cases and, in the course of several project meetings, recognized recurrent problems and comparability among the three cases with regard to the above-mentioned research objective.

The sample was composed as follows: (i) a company that operates in the electromechanical sector (hereinafter referred to as 'Mechanic'), based in Germany; (ii) a company operating in the chemical/pharmaceutical sector (hereinafter 'Pharma'), based in Germany; and (iii) a company operating in the energy sector (hereinafter 'Energy'), based in Italy

Table 1 – Sample characteristics

	Mechanic	Pharma	Energy
Industry/sector	Metal-mechanical	Healthcare and Agriculture	Infrastructure and services of the natural gas industry
Sector	Mobility Solutions, Industrial Technology, Consumer Goods and Energy and Building Technology.	Health, Agrochemistry and Innovative Materials	
Product/services	Mobility solutions, home appliances, software solutions, etc.	Pharmaceuticals, Crop Science, Animal Health	Transportation and dispatching, storage and regasification of natural gas.
Headquarter location	Gerlingen, Germany	Leverkussen, Germany	Milan, Italy
Headcount	410,000	116,998	3016
Headcount in the studied plant/branch	400	280	1900

Table 2 -Key characteristics of the Innovation program/Use case by company

	Industry	Product/services	Innovation program/Use case		
Mechanic	Metal-mechanical	Mobility solutions, home appliances, software solutions, etc.	Sensor solutions in the assembly department,	Launch of the Monitoring and Data Analytics applications	
Pharma	Healthcare and Agriculture	Pharmaceuticals, Crop Science, Animal Health Top of Form	Sensor Network System	Installation of the laboratory digital twin	Augmented Reality (Google glasses)
Energy	Infrastructure- natural gas industry	Transportation dispatching, storage of natural gas.	Digitization of corporate asset management		

(see Table 1 for the details of the three companies). All three companies met the following criteria: (i) extensive use of digital technologies, accompanied by substantial digitalization-driven organizational change; and (ii) organizational change processes inspired by STS principles, i.e., aimed at balancing social and technical aspects, with the overall purpose of reaching a high level of job quality, assessed according to the following criteria: (a) the organization had an employee-oriented human resource management system in place (e.g., was in the highest positions of the 'Great Place to Work' ranking, and/or had been accredited as a 'top employer' due to its constant focus on social aspects); (b) the organization's industrial and employment relations were open and collaborative (i.e., it had received high recognition in the industry thanks to highly employee-centered agreements); (c) extensive commitment to employee development and participation, as documented in the formal strategic documents as well as in the corporate social responsibility reports. Table 1 and Table 2 provide a summary of the main characteristics of the selected case studies and key characteristics of their innovation program.

Description of companies. MECHANIC operates in the electromechanical sector as a global provider of technologies and services. MECHANIC started in 2018 the 'datafication' of the assembly department in one of its Italian plants, aiming to increase the efficiency of production shifts scheduling and work coordination (team allocation). The digital technologies implemented include machine sensors and the installation of Monitoring and Data Analytics applications. The digital transformation has enhanced overall equipment effectiveness. The company can monitor in real time key performance indicators that are now shared on interactive dashboards, installed throughout the floor shop. PHARMA operates in the chemical/pharmaceutical sector and at the beginning of 2017 started the 'Innovation 4.0' program. Supported by consulting companies, PHARMA conducted feasibility studies and proofs of concept to design the digitalization of processes. After a year spent in designing, the company started implementing interim solutions, called 'quick and dirty', which immediately started to generate results. This phase lasted approximately 8 months and was completed in June 2018. At the time of the study, the company was adopting the following use-cases: implementation of augmented reality glasses that provided technicians with instructions on maintenance tasks, reducing downtime and increasing accuracy; implementation of the Sensor Network System, which collects data on production performance and communicates data to an interactive dashboard that monitors the progress of tasks; and the implementation of a digital work planning system for optimal resource allocation in the quality department. Finally, ENERGY, operating in the energy sector, aimed the digitalization of all the main phases of its corporate asset management. The company's objective was the integration of its IT systems, company databases and applications. The digital transformation was aimed at changing the work habits and daily routines of technicians, simplification of processes, including intervention reporting, elimination of paper-based work, reduction of error, increase in coordination (e.g., an information and interactive virtual 'toolkit' is now available for the operators), etc.

To operationalize the digital transformation process, multidisciplinary teams were set-up in all the three companies. At the MECHANIC plant chosen as the subject of the study, all departments were holding information-sharing sessions on a monthly basis, aimed at the identification of potential areas for optimization. During such sessions heads of various functions, together with other company profiles (such as corporate governance and support functions, production technicians, etc.) who had knowledge of the specific processes under review, played an important role in evaluating the need for innovation processes. These teams were also responsible for the generation of ideas/solutions through brainstorming, and for bringing to life the identified solutions, i.e., mapping the processes involved in a lean perspective to identify waste and inefficiencies, articulation of the technological design, and identification of the final solution (which can be robotic / technological and / or organizational). On the other side, PHARMA, supported by consulting companies, conducted feasibility studies and proofs of concept to design the digitalization of processes. Upon identification of the focus areas, use-cases were built with the collaboration of department coordinators, unit managers, shift heads, human resources, etc. Following this, three streams (of teams) were set up, each of which was respectively responsible for the identification of process areas, technological solutions, and people. In ENERGY, the digital innovation project was governed by a steering committee appointed by the board of directors. The project consisted of two macro phases. During the first macro-phase, the committee defined the vision (implying objectives related to technological innovation, process management, and work organization), developed intervention guidelines, and defined the new techno-organizational model. During the second macro-phase, 11 teams were set up in ENERGY that were responsible for the implementation of the digital transformation of asset management.

In all three companies the digital transformation was followed by a full re-designing of the operational process chain and a profound change in the organization of work. Special attention was given to the social system of the organizations. Indeed, in PHARMA, upon identification of the focus areas, technological use-cases were built with the collaboration of department coordinators, unit managers, shift heads, human resources, etc., whereby significant attention was devoted to the mapping of roles and competences. Also in ENERGY, the introduction of digital technologies was accompanied by a re-designing of processes, tasks, competences, and work organization. Although not always adequate and certainly lagging behind needs, a hierarchical corporate culture was weighing in, as the various functions were structured in 'silos' with little or no communicating bridges. Hence, the Company started to solicit and coordinate the necessary feed-back from the field and to promote numerous targeted workshops to address the change and involve people from different functions and roles.

Data Collection. The organizational change of all three companies was studied immediately after the start of the implementation of digital technologies, which took place between winter 2018 and spring 2019 for Mechanic and Pharma, whereas for Energy the main implementation occurred between 2015 and 2018. The timing was deemed appropriate since all three organizations had already completed multiple design and implementation cycles/stages. Our research designed a continuous process for data collection over a 6-month period.

The primary data source consisted of a few informal conversations, 14 semi-structured interviews with various professional roles involved in digitalization-driven organizational change, a number of observations, and one workshop. At Mechanic, interviews were held with the VP Human Resources and Organization South Europe, HR manager, Head of HR of the subsidiary plant, Head of Process Industrialization, Head of Digital Innovation, and Head of Maintenance. At Pharma, interviewees included the CEO, HR Manager, Talent and Change Manager, Head of Packaging Department, Head of Quality/Control (scheduling/planning), and Head of Production. At Energy, interviews were conducted with Head of HR, Asset Business Unit, Head of Operations and Maintenance Optimization. Information was collected using an interview guide designed to gather information in accordance with the high-level theoretical framework adopted in this study. The interview protocol was designed following the three (digital) STS principles developed by Winby and Mohrman (2018). The interview protocol focused on the following main areas: (i) company's key features, strategy, and history; (ii) technological innovations introduced and reasons for their introduction; (iii) digitalization-driven organizational change processes implemented; (iv) operative approach to organizational change (e.g., its design, phases, actors involved, methods used) with reference to the three (digital) STS principle developed by Winby and Mohrman (2018), i.e., integration of field of action across the ecosystem, extended stakeholder base, continuous approach to design; and (v) impact of the change processes. Each interview lasted between thirty minutes and two and a half hours, and all of them were tape-recorded and fully transcribed. To supplement the interviews, the researchers made use of written data that included both primary sources (organizational charts, presentations) and secondary sources (relevant Internet publications). The design and the selection of methods of inquiry during the interviews are indicative of a collaborative researcher-practitioner approach. Indeed, discussions and interviews with managers all shared the distinctive feature of focusing on actual organizational issues rather than on theoretical ones specifically

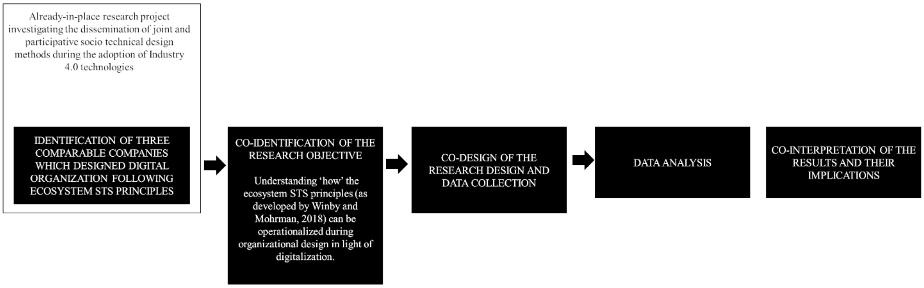

Fig. 1 – Overall methodological approach

designed for research purposes; therefore, most of the time the narration was started by the practitioners on real problems they had experienced.

Abductive data analysis. To analyze our data, we used a customized approach based on the research questions and the empirical context. This approach comprised four distinct phases of analysis. The first involved the creation of a case write-up – a 'chain of evidence' according to Yin (1994) – from case material that facilitated examination of the data. The selected parts, after comparison by the researchers, were aggregated and used to create a common database. The second phase involved the creation of a theory-informed thematic coding framework (Strauss and Corbin 1998). In this phase, recurrent content patterns were identified and organized into potential emergent themes. This procedure was repeated for each case. During this phase, whenever problems and inconsistencies arose within the research team, they were resolved by basing the interpretation on the identification of 'exemplar quotations' (Guest et al. 2012). During this phase the researcher-practitioner research team met and decided to further address the issue of external stakeholders. Hence, the research team set other specific objectives based on proposals from the practitioner team. The third phase consisted of cross-case comparisons (Eisenhardt 1989). Attention was focused not only on exploring similarities and differences among the three cases, but also on discovering new relationships. During this phase, the approach was mainly abductive (Dubois and Gadde 2002). Indeed, we used existing theory as the point of departure for reasoning; however, given the relative scarce body of research on the ecosystemic STS, the process was less theory-driven than deduction-driven (Ja¨rvensivu and To¨rnroos 2010), albeit we made use of the ecosystem preliminary framework for the analysis of results. However, the process was highly iterative, while the researchers strived to obtain a plausible and relevant match between the cases and the analytical framework. Triangulation of research techniques—such as workshops and interviews together with working meetings with case representatives (such as innovation/project leaders) — led also to a closer interplay between theory and the empirical world, also a means for a deeper understanding of our epistemic object (organizational practices). Such techniques also allowed us to develop reflexivity of thought (Cala´s and Smircich 1992) — representing another type of triangulation beneficial for the validity of findings (Denzin 1978). Figure 1 summarizes the overall methodological approach.

Findings – key Characteristics of the Ecosystem Organizational Design Processes

In what follows, we present findings related to the application of the (digital) STS principles stated by Winby and Mohrman (2018), in that we describe how the ecosystemic principles have been adopted by the observed companies.

Principle 1: Integration of Field of Action Across the Ecosystem

Winby and Mohrman's framework stresses that ecosystemic digitalization-driven change should integrate the design of digital technology and the social system at the ecosystem level. We now present how the observed organizations have applied the first principle.

Extended scope within and beyond company systemic boundaries. 'Process scope' concerns the extent to which different aspects of digitalization-driven change, such as strategic, technical, and social aspects, are considered. The observed companies approached the change in different ways. PHARMA and ENERGY initiated a dedicated 'digital' program aimed at the identification of the organizational units and external stakeholders most likely to be impacted by digital technologies, whereas MECHANIC embedded digitalization into its pre-existing innovation program. For example, the anticipation of socio-organizational issues in PHARMA and ENERGY took place at both program and local intervention levels. In both cases, systemic aspects had been addressed right from the early stages of the process. Indeed, all three companies developed a change framework that included analysis of: (i) the strategic domain, related to definition of the rationale that induced the company to adopt digital technologies, and also to the definition of the use-case selection criteria; (ii) the technological domain, with analysis of critical capabilities and work processes of the organizations, such as the selection of the digital technological solution at the beginning of the process; and (iii) the social domain related to the working conditions, the necessary skills and competences, and the definition of coordination mechanisms. ENERGY, for example, defined a strategy that not only included the integration of the asset management lifecycle, such as the definition of an integrated asset database and maintenance engineering and maintenance field activities, but also included organizational issues such as the need to change organizational roles. Guidelines provided in the strategic mission encompassed the future needs for resources and competences (e.g., the need for enhanced competencies of maintenance operators). In addition, the systemic change approach was inclusive of external stakeholders, such as suppliers and customers, who were considered important for accomplishing the business strategy. For example, Energy determined that involvement of external stakeholders right from the early stages of design was critical for achieving the desired outcome.

Systemic multidisciplinary approach. The second observation relates to the conceptualization of the interdependency of work among units and among various vertical chains of the organization's hierarchical structure, according to an approach that enables cross-functionality, cross-unit integration, and lateral decision-making. In all three companies the following criteria were used to determine the development of multidisciplinary teams: (i) competence-related criteria, meaning the inclusion of actors with knowledge and experience on the required subject matters; (ii) diversity-related criteria, meaning the inclusion of new employees with a basic knowledge of digital technologies or of employees with limited tenure; (iii) unit affiliation-criteria, meaning the inclusion of actors working in the organization units most impacted by the change, as these actors had a tacit knowledge of work processes and the corresponding social dimension. At MECHANIC, the temporary multidisciplinary teams in charge of implementing digital technologies, leveraged the pre-existing (stable) 'innovation' team. These temporary teams were composed of operational-level staff and line managers from all organizational units. In order better to evaluate the need for innovation processes, the aforementioned teams conducted monthly information-sharing sessions to identify potential areas for cost and measure progress. At PHARMA, in order to implement the innovation program in a multidisciplinary way, three systemic streams (teams) of work, all coordinated by the program leader, were responsible for the overall operations and for leading the design and implementation of digital technologies. All three teams were composed of members possessing different skills. The first team, focused on technological issues, sought to identify technological solutions; the second team, focused on management-related issues, was responsible for the identification of specific use cases; the third team, focused on organizational issues, was responsible for the redefinition of processes, corresponding roles, skills, and competences. To select team members, a set of qualitative data collection methods (i.e., expert interviews, focus groups, etc.) were used, which resulted in a multidisciplinary selection (from different units) and hierarchical non-linearity (from different organizational levels, including technology users, considered as bearers of subject matter knowledge). At ENERGY, differently, multidisciplinarity was achieved by establishing 11 teams responsible for the integration of asset management. Five of these teams were responsible for work methods, 4 teams for facility maintenance, and 2 teams for roles, skills, and training. Each team had 9–10 members including managers, technicians, team leaders, and other experienced or/and very young operators. The activity of each team was coordinated by a facilitator, or 'team leader', who was not necessarily a subject matter expert but rather acted as an integrator of different perspectives. Overall, in order to deliver value to a subset of customers and markets, all three organizations involved external actors. At ENERGY, for example, suppliers and customers participated in the identification of the technological solution.

Principle 2: Extended Multistakeholder base

The second principle, as propounded by Winby and Mohrman (2018), relates to multistakeholder participation, including external stakeholders. In what follows, we illustrate how all three observed companies implemented the principle.

Extended horizontal and vertical participation. This observation relates to the level at which participation takes place, namely task, functional, departmental, establishment, or corporate headquarters. The evidence shows that participation was extended horizontally, which means that, managers and employees were involved from all the main organizational units. Representatives of all functions and of the main processes actively participated by addressing technological aspects and human resource issues (at both company and plant level). In some cases, the global information technology team was also involved. In all three companies, participation was also extended vertically, in that employees from different hierarchical layers were involved. For example, at PHARMA and MECHANIC, the following actors participated in the various stages of the design and implementation process (i) in the early stage, department/process leaders, functional (line) managers, and IT personnel;

(ii) in intermediate stages, middle management, technicians, shift leaders, and lower-level employees (shift operators); (iii) in the final stages (design of the local solution), managers, technicians, shift leaders, and operators. In all three case studies, end users were involved in different stages of the design process, depending on the type of intervention or context. At PHARMA, for example, representatives from all hierarchical levels (even the lowest operational one) were involved in the design process. Operators at PHARMA were interviewed to provide their preferences about the digital dashboard. Indeed, during 'usability testing' of augmented reality glasses in PHARMA's production department, operators were broadly involved to obtain input from them. Also, at ENERGY employees from different hierarchical levels, including technicians and operators, were involved in all the stages of the design and implementation process.

Informative, consultative, deliberative, and creative participation. This observation relates to the degree of influence that participants had on the design and implementation processes. Depending on the specific phase and/or the specific intervention, the type of participation was different. Indeed, participants were invited to provide information either only during the definition of the problem or during the 'finding the solution' phase to actively participate in decision-making (i.e., participants chose between alternative predefined options), or to contribute creatively (i.e., participants became designers, and were called upon to furnish possible solutions). For example, in PHARMA, first-level operators and their supervisors were involved as informants in the early stages of the innovation process. End-users (such as operators) were involved during the problem identification phase and also during the development of the prototype phase to provide feedback. Differently, at ENERGY, all members of the 11 teams were creatively engaged during the phases of problem identification and definition of the solution, whereas field operators were directly involved in the selection of their work tools, a decision that directly impacted on their work habits and daily routines.

Direct and organizational participation. Finally, another observation concerns the form taken by participation at all three companies, i.e., 'direct' or 'organizational' participation. The former is related to involvement in the digitalization-driven change of individual employees; the latter refers to involvement in the digitalization-driven change of workers' representatives. At all three companies, there was a combination of direct and indirect participation based on the assumption that individual participation can never be representative of all the impacted workforce (especially in large-scale interventions). Consequently, all three companies sought union endorsement by adopting two different strategies. MECHANIC and PHARMA developed an informing/consulting relationship with the unions. Both companies constantly informed unions about the progress of the digitalization-driven change, mostly on issues related to employee control and the impact on workforce size. On the other hand, ENERGY created dedicated communication channels with unions, parallel to the pre-existing ones. Through a framework agreement, both parties committed to the management of organizational changes and the evolution of professional roles related to digitalization. The monitoring of contractual clauses was entrusted to a Joint Technical Commission which addressed, inter alia, issues such as privacy regulations and use of employee work-related information. The Joint Commission contributed to the definition of a training and development plan which impacted on approximately 550 employees. The plan was recognized to be a key change management intervention for supporting employees in identifying opportunities for further professional development and aimed to be inclusive of all interested stakeholders. To have an effective participatory model, all three organizations leveraged the formal organizational structure (e.g., organization charts or procedures) and extensive training for operators. Moreover, they developed a communication strategy connected to the 'extended participation' objective. For example, to communicate the ongoing changes to all its employees, on several occasions PHARMA halted the production process (the company works over a 24-hour production cycle). Other in-depth communication tools, such as individual meetings with operators, were also used to achieve technology acceptance.

External stakeholder participation. All three observed organizations extended the system boundaries of stakeholder involvement. For example, at ENERGY, suppliers were involved as an integral part of the digitalization-driven change as their feedback on the 'asset integration' model design was considered to be important. The exchange flow with suppliers actually characterized all the phases of the change process. Selected suppliers to ENERGY, for example, participated in the definition of the functional requirements analysis phase and in the experimental process of prototyping. For example, as the old IT systems (whose complexity had significantly reduced their usefulness to suppliers) were gradually replaced by the newer IT system, suppliers were involved in the design and implementation phases of the new technological process. Moreover, customers were also involved and requested to provide feedback (data) necessary to better determine the quality of the product/service. At ENERGY, customers were involved during the 'problem definition' phase (by completing questionnaires related to various design functional issues), as well as during the 'product design' phase, when they had the opportunity to provide their input during the demonstration of various technological solutions (prototypes).

Principle 3 Continuous Approach to Design

In their third (digital) STS principle, Winby and Mohrman (2018) state that "designs will be seen by as temporary, or even fleeting waystations on the journey", thus alluding to an approach to systemic design to be based upon an ongoing iterative learning process and continual exchange of information among ecosystem participants. In what follows, we present our results showing how the three companies applied this principle.

The approach to the change process is simultaneous and systemic. In all three cases, the approach to digitalization-driven change was not defined according to a traditional perspective. Instead, the approach to design is meant to be a continuous, participatory, learning process in which planning and doing occur at the same time. For example, the process releases and final deliverables were broadly defined and were not produced in advance (the goal definition phase ended upon achievement of a certain outcome; the same should be true for the definition of specifications phase and the feasibility phase). The process phases were thus not sequentially connected, and each of them was managed by a different team which was dismantled at the end of the phase. Phases were thus not managed assuming sequential interdependencies (phase A precedes B; that is, phase A produces an output that is used as an input to phase B), but instead through mutual interdependencies (phase A and phase B produce outputs which in turn are used by each as necessary input; therefore, team activities proceeded in iterative cycles). These methodological considerations ensured the simultaneous management of issues and challenges from different domains (strategic, social, and technological) as different nodes of one process, rather than separate sequential steps. At ENERGY, this systemic non-sequential approach was leveraged by the development of different teams (operating in different domains), simultaneously active and constantly in contact with each other. For example, for each use case, in order to ensure the alignment of local organizational choices with the vision of the organization, the steering committee (whose strategic goals included the definition of process objectives and supervision of work progress) interacted in a structured way with the teams responsible for the development of technological solutions and the teams operating on the design of the organizational solutions.

The change process as a learning process, iterative and based on continuous experimentation. This observation relates to the extensive use of change methods based on continuous experimentation and iterative cycles. These methods are typically called 'agile', referring to the way that the phases and the respective teams were structured. Consistently with the agile perspective developed in the IT field, the phases of the digitalization process proceed in a non-sequential logic (i.e., the team in charge of phase A works and then 'leaves room' for the team in charge of phase B) predicting constant temporal overlapping (the team in charge of phase A works while the team in charge of phase B also works). The reason why all three companies adopted this approach is that the digitalization-driven change process (exactly as in IT projects) assumes that recycling, and thus altering or refining already-made decisions, is a necessity or rather an opportunity for reaching the best solution. All three companies preferred the methods borrowed from this agile approach to a traditional planned change approach. Consequently, a broad set of actors were involved in prototyping the solution to collect their ideas and provide feedback, and the design process ended with quick user testing of preliminary solutions to verify their goodness of fit and to introduce necessary modifications accordingly. For example, at PHARMA the usability testing of 'quick and dirty' solutions with operators was used as a technique to explore multiple, alternative solutions simultaneously, and investigate ill-defined problems where many factors might be unknown. At ENERGY, the approach was inclusive of suppliers and customers. Further evidence relates to the fact that in all three companies, the change methodologies applied leveraged the active involvement of a broad set of stakeholders during the phases of problem definition and solution identification. Indeed, the change approaches adopted by the three companies foster broader stakeholder participation and encourage their coordinated interaction for the design of creative solutions, remaining unconstrained by path dependency and other limitations. This is consistent with the approach that several companies are today adopting in new product/service design, where it takes the name of 'design thinking'. At ENERGY, for example, design thinking methodologies directly and intentionally borrowed from new product/service development were used to stimulate team members to think and act like designers. Similarly, at PHARMA, the leader of digitalization-driven change conducted brainstorming sessions explicitly following methods typical of design thinking, whereby participants were encouraged to unlock their creativity and propose alternative solutions. The above evidence shows that the observed companies undertook the change of their techno-organizational system by formally and informally adopting methodologies originally developed in other fields, i.e., the IT field for the agile approach or the new product/service development field for design thinking.

Discussion

Given the techno-centric stance on the effects that digital technology has on work and organization, a socio-technical approach to organization design is required to address the resulting gap between the technical and human elements of the organization in light of digital transformation. To that end, the ecosystem digital socio-technical approach to organization design provided by Winby and Mohrman (2018) is reflective of the continuous and rapid advances in digital technology, the boundaryless world that has resulted from them, and the fundamental changes regarding internal and external stakeholders. Given the limited understanding of the specific dimensions of an ecosystem STS design, in this work we have sought to build upon Winby and Mohrman's analytical path and examined how the ecosystem STS design principles, as developed by them, were applied in three large manufacturing companies that have changed their organizations following the ecosystem socio-technical design approach in light of digital transformation.

Our empirical results show that the STS design approach adopted by all three companies is encouraging a symmetry among people, work, technology, and the environment where the firm operates, in a never-ending process, constantly generating solutions and routines to achieve holistic outcomes across systems. Thereby, it is the actual application of the third STS principle, 'a continuous systemic approach to design' (see Table 3), a quasi-in-built capability, applied through the adoption of 'agile' and 'design thinking' methods (borrowed from the IT field and the new product/service development field, respectively) that enables companies to approach change through short, iterative, and continuous experimentation cycles, which in the past – and in many cases, still today –management scholars and practitioners only considered in a sequential and separate manner (as in the case of the 'waterfall methods'). Such methods also support the mutual adaptation of employees, users, environment, and technology designers in a more spontaneous and organic way than the slower, more deliberate design process espoused by the STS founders.

As work in the new ecosystem STS design approach is shaped and integrated between the technical (digital platform) component and the social component (employees, contractors, suppliers, customers, etc.) in order to achieve holistic outcomes across them, such findings are also indicative of the changing character of the hitherto conceptualized STS work system. Indeed, as work activities pass from one cross-boundary agile team to another, the employee part of the work system is built around such agile, project-based development, and production teams consisting of engineers, data scientists, managers, app developers, technology end users, and/or other roles, responsible for continuously improving the platform. Improvements are in turn driven by user feedback and broad participation during the technology design and by analysis of the flood of data coming in from the user/customer/supplier interface. The digital platform mediates among all stakeholders, thus eclipsing the shop floor work system, as the boundary between the shop floor and the whole organization is dissolving; this is a characteristic or an outcome of the dynamic context, which in turn has implications for STS organizational design theory, indicating a need for an enlarged notion of the work system in the context of the digital transformation.

Table 3 -Principles and actual operating applications (Winby and Mohrman 2018) that characterize the design process

STS Principles	STS applications	EXAMPLES FROM OBSERVED COMPANIES
Integration of field of action across the ecosystem	Extended scope	Pharma – Since the beginning it has been envisaged that the scope be expanded to include issues pertaining to three areas: strategic, organizational, and technological. Each of these aspects was assigned a dedicated team.
		In Energy, the process's scope and vision broadly defined the expected outcomes, including both technical and social elements. In addition, the overall strategy-driven view of extended organization design aimed to cover the entire life cycle of the asset, meaning the involvement of external stakeholders
	Multidisciplinary approach	In Mechanic, dedicated teams were created for and assigned to the Digital Process, as part of a more general framework of continuous innovation program. The teams had monthly meetings. They consisted of staff members with different disciplinary skills and backgrounds.
		In Energy, 11 teams were set up and given the responsibility of defining a new techno-organizational model (for processes and systems). Each team included members with different disciplinary skills and backgrounds
Extended Multistakeholder base	Horizontally and Vertically Extended Participation (Internal Focus)	The 11 teams in Energy were composed of individuals from different hierarchical levels (vertical participation) and different functions (horizontal participation)
		In Mechanic, the implementation of each individual use case was assigned to a dedicate teams composed of representatives from different functions (horizontal participation) and different organizational levels (vertical participation).
	Inclusion of external stakeholders such as suppliers and customers (External Focus)	In Energy, suppliers and customers participated in the design and implementation phase, as their feedback on the 'asset integration' model design was considered important. Selected suppliers in Energy took part in 'the definition of the solution' phase and also in the 'definition of the solution', as technological prototypes of the solution were presented to the main global suppliers. On the other side, clients provided feedback (data) necessary for the company and were also involved in the 'product design' phase by being presented the various prototypes.
	Informative, Consultative, Deliberative, and/or Creative Participation	In Pharma, technology users and their supervisors were involved from the start of the design process. Participation ranged from being merely informative/consultative to having a more strategic role in later phases (deciding among different design solution alternatives) or generating ideas related to final solution specifications (creative participation)
		In Energy, the members of 11 teams participated in the generation of solutions (creative participation), whereas technology users (field operators) were involved in selecting their work tools (decision-making participation)
	Direct and Indirect Participation	In addition to individual participation, Mechanic and Pharma used the existing communication channels to also involved workers' representatives in the development of the digital program development and related specific interventions as well as in matters regarding employee control and the impact of digital technologies on workforce size (organizational participation)
		In addition to individual participation (direct participation), Energy entered a company-union agreement related to the innovation process. A joint commission was set up for monitoring its progress (indirect participation).

Table 3 (continued)

STS Principles	STS applications	EXAMPLES FROM OBSERVED COMPANIES
Continuous approach to design	Design Process is Simultaneous and Systemic	In Pharma, three teams worked simultaneously to identify possible techno-organizational solutions. Brainstorming sessions were held to encourage the generation of participatory creative solutions, regardless of past experience.
		In Energy, the 11 teams worked simultaneously, although on different topics. Members were engaged in imagining new solutions, regardless of what had been done thus far and of existing constraints.
	Design Process is Iterative, based on Continuous Experimentation	In Pharma, a solution-based approach was preferred, such as carrying out some form of prototyping, usability testing of 'quick and dirty' solutions with operators, rather than waiting to test the final product.
		In Energy, the 11 teams were constantly exchanging views and information and were engaged in different prototyping and testing cycles.

Data availability statement

Dear editorial team,

Conclusion

Theoretical Implications

Given the scope of our research, we extend Winby and Mohramns's digital STS framework, as we deconstruct the 'how' and 'who' of organizational change (how do we change, who is change for) in light of digital transformation, while also investigating the 'what' of change. Thereby we also address and provide an answer to several calls from scholars (such as Schwarz and Vakola 2021): "what exactly is organization change?". By placing such an emphasis on both the 'what' and the 'how' of the approach to ecosystemic sociotechnical change, we hope to extend our contribution to the realm of applied change management research and ODC scholarship. In particular, our findings suggest that traditional management and ODC research and theory should be expanded in order to include models and methods from other domains. Indeed, whilst traditional management and ODC research focuses mainly on the 'what' of organization change, hybridization with domains such as IT and/or new product/service development may open theoretically interesting research avenues on the 'how' of such change. Specifically, for applied research to advance it would be important for the ODC field to integrate new multidisciplinary design methods, as argued by Schwarz and Vakola (2021), resuming the multidisciplinary view that many years ago was at the heart of the STS theory. Such integration would enable (applied) management and ODC scholarship to start exploring and designing the (necessarily multidisciplinary) models, techniques, and tools of the future, thus avoiding the adoption of a purely academic, retrospective perspective on change.

Finally, the collaborative nature of this study, where researchers and members of observed organizations worked together as partners to address ecosystem sociotechnical issues, also adds to the creation of actionable knowledge on organizational change in light of digital transformation. Thereby, the educational workshop held by the researchers with different stakeholders (e.g., members from the observed companies, media representatives, union representatives, etc.) also played a part in bringing research and practice closer to each other. The workshop presented an opportunity to discuss research learning outcomes as well as limitations and practical implications of this study.

Practical Implications for Industrial Activities

This study offers practical insights for practitioners operating in industrial companies that aim at making digitalization an opportunity for designing more human production and organizational processes. Indeed, our elaboration of design principles (see Table 2) provides multifacet guidance for practitioners to manage the ecosystem dynamic adaptation: how to digest internal and external adjustments to the digital transformation process (see column 2), what to do, how, when, and with whom. To this end, by providing practitioners with clear goals right from the start of the project and involving them throughout the process of knowledge production (Dhanaraj and Parkhe, 2006), this research work contributes to taking actionable steps in promulgating the 'how' of ecosystem STS design and to shortening the researcher-practitioner gap.

Limitations and Direction for Future Research

The boundaries determined by the rapidity of technological advancements are bound to merge more closely in the future, and therefore we also wonder what the future social implications of this will be, since the digital transformation will further eclipse work systems as we know them and will hence have further implications for the systemic conceptualization of STS. Such work system may empower stakeholders to address their purposes and interests, as they can also constrain them to a life that is shaped by others. Thereby, looking at work and organization change through socio-technical lenses becomes ever more important.

Given the above reflections and implications, we hope that our study will motivate other researchers to explore the evolution of ecosystems and STS approaches. As we have acknowledged in our limitations, there is a need to add more variables with respect to STS ecosystems, appreciating the multifacetedness of organizations, and also taking into consideration ecosystems of different sizes and structures as well as the different features of digital technologies. New and innovative methodological approaches and data should be embraced that further the evolutionary perspective of STS ecosystems, as suggested by Wurth et al. (2021). In particular, future studies might investigate differences among the structural features of organizations, and may also differentiate among the other various factors that drive organizational change. Exploring what such factors might mean for organizational design would enrich the understanding of the organizational design process in light of digital transformation and help research better map the results achieved in this study. Moreover, as our empirical gaze was focused on three large firms which have a standardized and mature management system, the investigation of firms that lack such a level of standardization of management information, may be indicative of different patterns on how to manage the digital transformation. Building on such foci, further empirical studies are warranted to investigate the trigger event(s) and the wider antecedent contextual conditions. Finally, we hope that our study may motivate examination of the various ecosystem actors and how they evolve over time to support joint optimization of the ecosystem.

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Declarations

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