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Editors:

Margaret Malloch – marg.malloch@vu.edu.au

Len Cairns – len.cairns@monash.edu

Bridget N. O'Connor – bridget.oconnor@nyu.edu

Karen Evans – karen.evans@ucl.ac.uk

Chapter Title:

The transformation of learning: From learning organizations organizations to a landscape of ecosystems

Authors:

Maarit H. Virolainen, University of Jyväskylä, the Finnish Institute for Educational Research (FIER), Jyväskylä, Finland

Hannu L.T. Heikkinen, University of Jyväskylä, the Finnish Institute for Educational Research (FIER), Jyväskylä, Finland

Sirpa Laitinen-Väänänen, School of Professional Teacher Education, JAMK University of Applied Sciences, Jyväskylä, Finland

Juhani Rautopuro, University of Jyväskylä, the Finnish Institute for Educational Research (FIER), Jyväskylä Finland

Contact person:

Maarit H. Virolainen, Maarit.ha.virolainen@jyu.fi

University of Jyväskylä, Institute for Educational Research

Postal address: P.O. Box 35

Postal code: FI-40014, City (post office): University of Jyväskylä

Country: Finland

Chapter abstract:

This chapter examines how the idea of the 'learning ecosystem' has emerged in the discussion on learning at work. It presents how the 'ecosystem' discussion has to some extent replaced former conceptions and theorizing related to learning and work in organizations, such as learning organizations, learning regions, university–government relations, and national innovation systems as well as networks and the actor–network approach; and examines the expansion of the utilization of the new 'ecosystem' concepts. The transformation toward the new 'ecosystem' discussion is related to the adoption of new technologies for information sharing, exchange and communication as a result of industrial revolutions, the latest being 'Industrial Revolution 4.0'. The adoption of new technologies has coincided with the shift from the classic bureaucratic organization toward a landscape of ecosystems. In conclusion, we discuss the demands set for research on learning and work related to the landscape of ecosystems.

Keywords: ecosystem, learning organization, national innovation system (NIS), actor–network theory (ANT), industrial revolutions

Introduction

New concepts, such as 'digital learning ecosystem', 'learning ecosystem' and 'ecosystem of learning', have emerged. These new 'ecosystem' concepts aim to grasp the change that has taken place in the contexts of adult learning and work in organizational settings. Further, terms such as 'business ecosystem' and 'innovation ecosystem' have become popular concepts when referring to collaboration between organizations. Our chapter explores the emergence of these concepts in relation to the adoption of new information communication technologies. It also presents central conceptions and research approaches that preceded the expansion of 'ecosystem' concepts. It shows how the understanding of the context of learning has been transformed toward ecosystem conceptions. The research question underpinning the chapter is: *How have the conceptions concerning organizational contexts of adult learning and work transformed?* Further, we examine how the conceptions about knowledge production and utilization in organizations have transformed. The aim is to increase the understanding about how the changing context of adult learning has had an effect on how the adult learner and learning have been perceived in different historic periods. The explored conceptions depict how the organization of learning and work has evolved as the development of information and communications technology has enabled new models for exchanging, crafting and storing knowledge and information.

In this chapter, we examine how the discussion about ecosystem concepts has expanded during the first decade of the 21st century. We argue that these various ecosystems form a landscape of ecosystems where they overlap and form collaborations of expert networks

across various organizations in the world of work. In contemporary societies, ecosystems situated a long distance from one another are connected through digital technologies. Thus, ecosystems situated on one continent may have nodes, individuals and teams of collaborators on the other side of the globe. The effects of this transformed societal context for the experience of the adult learner has been described by referring to the new forms of learning as 'liquid learning' and the learner as a 'liquid learner' (Barnett, 2012). The liquid learner has to come to terms with multiple real life and distant, virtual learning contexts across his or her life span. This metaphor has been suggested to capture the qualities demanded from the learner, who should be prepared for the unexpected and uncertainty while moving between learning spaces. The learners have to cope with more fragility regarding the interconnections between learning contexts (Barnett, 2012). Further, the term 'rhizoactivity' has been suggested to 'capture the multiplicity of learning that always makes connections to anything else and pursues heterogeneity' (Kang, 2007, p. 207). While these terms portray, from the learner perspective, how there has been a change away from depicting a unified social learning context for adults toward a multiplicity of possible contexts, this chapter presents the transformation of organizational contexts of adult learning through an overview of the central conceptual approaches.

Accordingly, we introduce the development of concepts, such as digital learning ecosystems, business ecosystems and innovation ecosystems. As background, we first describe their precursor concepts, such as learning organizations and learning regions. We further examine the concepts that have been proposed to capture the chains of knowledge production, adoption and utilization across organizations for the benefit of society at large, such as university–government relations, national systems of innovation (NIS) and networks, actor–network approaches and actor–network theory. Through this overview of conceptions, we depict the long-term shift from bureaucratic organizations toward the landscape of ecosystems, and then connect the shifts to the parallel four industrial revolutions in order to show how the technological changes have had in-depth effects on the organizing of adult learning. Finally, we then conclude by discussing the impacts of these transformations on work and education, and consider the needs of learners and the need for further research.

From learning organizations to ecosystems

Firstly, we discuss the forms of organizing adult learning and facilitating learning in work contexts that were developed to improve work practices as well as knowledge production, adoption, utilization and management within one organization. After presenting the 'learning organization', we discuss the concepts that underlined facilitating the exchange of knowledge and interaction between organizations. Adult learning in these organizations, and their collaborations, were seen as a vehicle for change, development and innovation before the transformation of the adult learning context into an ecosystems landscape.

Learning organizations

In the 1990s, knowledge exploitation and exploration were the focus of a number of organizational researchers, such as March (1991) as well as Nonaka and Konno (1998), since these were viewed as crucial assets for business and industry organizations in addressing the turbulence of their operating environments. For example, March (1991) provided an elaborated model that theorized there to be ecologies of competence between organizations. For March (1991), organizational learning, analysis of performance, and adaptation were key

to building a high-performance organization. In parallel, Nonaka and Konno (1998) became famous for their Socialization–Externalization–Combination–Internationalization model (i.e., SECI model) of organizational learning. Their model depicts processes that can be planned and taken up by leadership within an organization to take advantage of new knowledge and create more effective practices. The SECI model brings up central phases for learning organizations to promote (Nonaka, Toyama, & Konno, 2000). In each of the phases, the utilization of new knowledge and practices is fostered and expanded in the company. According to the SECI model, an organization can evolve and adopt innovations through consecutive phases, for example, by first explicating tacit knowledge and experience, and then capturing and explicating new knowledge. Thereafter, it can proceed by internalizing the knowledge within the practices of the company through individual and peer learning, and by utilizing devices with both face-to-face communication and information technology features (Nonaka, Toyama, & Konno, 2000).

Overall, the increased interest in learning in organizations brought up the importance of understanding learning in teams. Accordingly, team learning became a new focus for research (Kasl, Marsick, & Dechant, 1997; Mumford, Scott, Gaddis, & Strange, 2002; Yorks, Marsick, Kasl, & Dechant, 2003; O'Leary, Mortensen, & Woolley, 2011). At the same time, while theories of organizational learning evolved, the networks of expertise formed between educational institutions and the world of work gained interest, particularly from the perspective of educational institutions (Hakkarainen, Palonen, Paavola, & Lehtinen, 2004). The interest in taking better advantage of the latest knowledge for the benefit of national economies and formulating policies aiming at the promotion of industrial development through innovation was in part channelled by the discussions on learning regions and university–government–industry relations.

Learning regions and university–government–industry relations

The ideas of the Triple Helix (Etzkowitz & Leydesdorff, 1995, 2000; Etzkowitz, 2017) and learning regions (Florida, 1995) gained sway in theorizing regional development as contexts for learning organizations in the 1990s. They portrayed research, higher education and regional development as being in vital relation to one another. In particular, the importance of universities for promoting innovation in knowledge-based societies was underlined.

In the discursive era of the 'knowledge economy', access to knowledge was seen to be crucial for the promotion of national wealth (Välimaa & Hoffman, 2008). For the developed national economies, the emergence of the 'knowledge economy' marked a shift from factory-based production toward economies driven by investment in knowledge-intensive areas, such as research and development, education and software development, as well as industries which were characterized by the adoption of the latest high-tech innovation to enhance their competitiveness in the global market (George, 2006; Bastalich, 2010).

Universities were expected to take a leading role in supporting the transformation of industries and national economies, and were to step from what was referred to as Mode 1 to Mode 2 learning, that is, to shift from traditional discipline-oriented and hierarchically organized knowledge production, with its essential focus on knowledge production rather than application, toward multi-disciplinary, socially accountable practices enabling economy-boosting innovation (Gibbons et al., 1994). This brought about a major shift in how the role of the university and research was seen vis-à-vis society. In Mode 1, knowledge production

was rather academy-driven, since research problems were set out by the disciplinary community and their solution was governed by the interests of specific academic disciplinary communities. Scientific knowledge spread into society once it was picked up and it potentially enabled innovation, but innovation was not the primary target. In Mode 2, in contrast, instead of consecutive phases of knowledge production and possible application, knowledge was to be produced in the context of its application in the collaborative research units of universities and companies (Gibbons et al., 1994). Knowledge production in Mode 2 was thus oriented toward more practical, outcomes-oriented problem solving. It was to be transdisciplinary and conducted through participatory processes in a reflexive and dynamic manner.

In practice, despite new forms of collaboration, the old disciplinary forms of organization have survived, and Mode 2 knowledge production nevertheless interacts with Mode 1 knowledge production (Gibbons et al., 1994). In the next phase of higher education–government–industry relations, in Mode 3, the higher education system was expected to be conducive to the creative combinations of Modes 1 and 2 in a reflective manner (Carayannis et al., 2016). In Mode 3, regional actors should aim to actively build creative environments for knowledge production and application, while taking advantage of both Modes 1 and 2 in terms of organizational forms of knowledge creation, production and application (Carayannis et al., 2016). In Mode 3, higher education institutions are assessed and addressed through the lens of 'epistemic governance', involving quality policies and measures that acknowledge underlying knowledge paradigms (Carayannis et al., 2016).

Later, as the vision of potential collaborators for universities and research units expanded, concepts like the Quadruple Helix and N-Tuple Helices were further suggested, highlighting the multiplicity of possible collaborative arrangements (Leydesdorff, 2012; Kolehmainen et al., 2016). The Quadruple Helix added a broader community consisting of local and regional civil society and its users, citizens, to the collaborators of universities, business and regions, and envisioned them all driving toward innovation. The N-Tuple Helices meant further increasing the number of collaborative partnerships. In sum, these concepts underlined the opportunities for collaboration between the research and education sector and local businesses and communities, public administration and city residents, as well as for investors and the media to foster local development (McAdam & Debackere, 2017; Muhyi et al., 2017).

At the time that Mode 3 university–government–industry relations were proposed, some researchers had already suggested that the analysis of organizational relations should be replaced by the analysis of networks. Networks were seen as evolving or having semi-autonomous dynamics and exhibiting segmentation, that is, lock-ins and lock-outs across organizational boundaries (e.g., Etzkowitz & Leydesdorff, 2000). Also, empirical research revealed the complexity and diversity of university–government–industry relations (Vielba & Esquinas, 2012).

The shift from Mode 1 to Mode 3 is a key example of ideas through which the context of adult learning, knowledge production and adoption in organizations became exposed to the possibilities of national competitiveness and economic growth (see also Lundvall, Johnson, Andersen, & Dalum, 2002). The adult learning context in organizations and society met increased demand for lifelong learning to foster individual development, well-being, active

citizenship and employability, as well to benefit national economies (Pépin, 2007; Lee, Tyver, & Madyun, 2008). On the side of the new emergent Modes for knowledge production and utilization within university–government–industry relations, the concept of a National System of Innovation (NSI), presented next, was developed to highlight the importance of rethinking the relations of companies, universities and nation states.

National systems of innovation

As knowledge exploitation was seen to have crucial importance for the success of national economies, the idea of a National System of Innovation (NSI) was employed by evolutionary economists. They introduced it to advance the ideas of organizational learning and regional development (Nelson, 1993; Freeman, 1995). This idea underlined the importance of national policies for promoting innovation creation and knowledge adaptation through networks across research and development actors, higher education institutions and companies. The NSI provided a powerful means of conveying the significance of the relationships between innovation and learning organizations for development cooperation. In contrast to the Triple Helix discussions, which placed the emphasis on universities initiating innovation, the NSI was seen to underline the importance of actions by private companies (Etzkowitz & Leydesdorff, 2000). Examination of debates from the period 1990–2010 reveals that although the debate about reorganizing university–government–industry relations was still in flux, the characteristics of helices, learning regions and the NSI were already intertwined in national policies. Institutions of (higher) education and enterprises were seen as playing a crucial role in the NSI of many national economies, which resulted in the development of related policies in the Nordic countries and elsewhere (Schienstock & Hämäläinen, 2001; Lundvall, Johnson, Andersen, & Dalum, 2002; Brundenius, Göransson, & Ågren, 2011). The idea of NSI became widely diffused and absorbed by organizations such as the OECD (Organisation for Economic Cooperation and Development), the European Commission, and the US National Academy of Sciences (NAS) (Lundvall, Johnson, Andersen, & Dalum, 2002). In contrast to the conceptions of learning regions and the NIS, the network approaches presented a different focus for social organization across contexts. The actor–network approach emphasized the spread of new ideas and technologies through combinations of human and non-human actors. It brought up the material side of transforming relations. The network approach was a further important step and conception that redefined the adult learning context prior to the emergence of the ecosystems landscape. The network approaches are described next.

Network and actor–network approaches

In the 1990s, the Internet enabled faster communication within organizations through e-mail, webpages and intranets. Today, the World Wide Web is ubiquitous and accessible around the globe via mobile phones. It has deeply changed everyday life, including when and how people communicate with each other. In the 1990s, social scientists, such as Manuel Castells (1997), envisioned the beginning of this new Information Age. Castells (1997) described the network enterprise as consisting of multinational corporations, or their segments, that can differentiate, decentralize and form a web of subsidiaries and suppliers throughout the world or build strategic alliances together with other companies. Castells' vision became popular

across the humanities and social sciences. However, networks had been studied by social scientists long before Castell. Interest in networks took root after the Second World War, and it gained momentum in the 1960s and 1970s along with the expansion of the higher education system (Eriksson, 2015).

During the 1950s and 1960s, European and Anglo-American network research formed two major traditions (Eriksson, 2015). The European social scientists—such as Gille Deleuze, Michel Foucault, Michel Serres, Bruno Latour, Michel Callon and Luc Boltanski—are seen as having built, on somewhat common ground, a critique of structuralism in the social sciences (Eriksson, 2015). Meanwhile, Manuel Castells and Mark Granovetter have been central figures in the Anglo-American tradition of theorizing networks (Eriksson, 2015). In particular, the actor–network approach, developed originally by French scholars Latour and Callon, has gained considerable interest in education research (Edwards & Fenwick, 2015; Rimpiläinen, 2015; Sriprakash & Mukhopadhyay, 2015; Thumlert, de Castell, & Jenson, 2015; Fenwick & Edwards, 2019). Recently, the approach has been utilized to study the formation of actor networks in the context of learning and education, which is why we turn to it next.

Actor–network approach

The actor–network approach can be seen as a methodological approach rather than a uniform theory. It is, however, often referred to as the actor–network theory (ANT). Its origins are rooted in developments in the sociology of science during the 1970s and 1980s. In particular, Michael Callon's study of an attempt to build an electric vehicle in France has been seen as the starting point of the approach (Callon, 1987; Muniesa, 2015). In the debates about the sociology of science at the time, the ANT approach defended combining constructivist and realist approaches for the production of scientific facts (Muniesa, 2015). The ANT approach underlined the importance of studying the conjunctions of human and non-human agency and paying attention to both the intentional and unintentional outcomes of practices combining multiple intervening players. These players involved and ranged from, for example, the personal interests of the scientist to normative codes of conduct and research funding. The recipe that ANT provided for empirical study was to explore how a planned program of action becomes materialized (or not) and how it intervenes in other such plans, social practices or codes of conduct to form a network of actors, which might combine humans and non-human devices or entities. The outcome of the activities was not to be understood as predetermined but rather in-the-making (Muniesa, 2015).

A classic example of the ANT approach is Latour's (1988) study of Louis Pasteur's microbiology laboratory. It is an illustrative example of how the translation of scientific findings, such as the fact that the anthrax bacillus can circulate through society's various actors, and referential operations can inform change in multiple practices, in this case farming. From the ANT methodological perspective in general, the duality between agents and their social dependencies and conditioning was questioned. In studies on drug addiction, the approach demanded shifting attention from 'moving' to 'being moved' by drugs, thus underlining the effect of non-human actors (Muniesa, 2015). The central concept used in ANT studies has been 'translation', which refers to how scientific facts are determined and how the understanding of studied objects is translated step by step. In the words of Fenwick

and Edwards (2011, p. 4), one entity works upon another to change it and thus becomes a 'part of a network of coordinated things and actions'. Accordingly, when terms are moved around in society they connect with one another, and, in so doing, they change our understanding about their relation (Law, 2009). Furthermore, the process by which interest in a new object of study translates the object and studied material, as well as the learner community, is referred to in actor–network theory as unfolding in four phases: problematization, interessement, enrollment, and mobilization (Callon, 1984; Burga & Rezania, 2017).

From the perspective of studying ecosystems of learning, the ANT approach could inspire, for example, further empirical studies on how building digital learning environments has reorganized teacher–learner–workplace relations within or across ecosystem nodes, or how the digitalization of learning as a program of action has changed teachers' pedagogical choices. Thumlert, de Castell and Jenson (2015), for example, have studied the relationship between technology and education from the perspective of the actor–network approach (see Fenwick & Edwards, 2019). While the actor–network approach underlines the importance of actor–network relations, it has been criticized for downplaying the importance of the boundaries between networking communities, as well as not paying enough attention to the driving forces of agents' actions, such as consciousness, directedness, concern, understanding, will, and decision making (Miettinen, 1998; Brown & Capdevila, 1999).

In sum, the discussions on learning organizations, learning regions, university–government–industry relations, national innovation systems and actor–network theory preceded the origin of the ecosystem approaches in research. They were not adopted univocally and did not expand in a linear way; rather, each has been favored by particular research communities. We argue that the gradual definition and formation of the 'business ecosystem' and 'innovation ecosystem' (Gomes et al., 2018) is indebted to these prior discussions prevalent in the 1990s. In the field of research on individuals' development and learning, Urie Bronfenbrenner's conceptualizations with respect to systems influential to human development have become well-known (Rosa & Tudge, 2013; O'Toole, Hayes, & Halpenny, 2020). Meanwhile, these approaches, considering learning organizations, regions and networks, have been effective in pointing out the connections between specific contexts for learning and their meaning for fostering societal development.

We argue that the emergence and formation of business and innovation ecosystems and digital learning ecosystems has been dependent on the appearance of digital communication systems as well as the previous conceptions. In this next section, we portray how these ecosystems denote a major shift in organizational formation and learning across contexts between learning and work. The adoption of new ecosystem conceptions reflects a shift in industrial revolutions. The convergence took place at the transformation from the Third to Fourth Industrial Revolution. At the same time, the emergent ecosystem conceptions reflect a turning point in theorizing organization, networks, regional development, and university–business relations.

The formation and expansion of ecosystems

Business ecosystems and innovation ecosystems

The concept of the ‘business ecosystem’ was initially proposed by J. F. Moore in the 1990s (Moore, 1993; de Vasconcelos Gomes et al., 2018) and was based on an analogy between companies and natural ecosystems. This vision of corporate interrelations was ground-breaking: Moore suggested that companies should form ecosystems across several industries rather than focusing only on one industry and one field of production. Moore’s seminal article (1993) envisioned how companies could cooperate across industries to take advantage of innovations. Such cross-sectional cooperation enables the co-evolution, creation, combining and marketing of new products and services. From this perspective, business ecosystems were to evolve through fierce competition and the following four stages, consecutively: birth, expansion, leadership of the market, and either self-renewal or death (Moore, 1993).

The fight between business ecosystems was pictured as analogous to natural ecosystems: business ecosystems were to struggle like lions and antelopes for expansion in their environments (Moore, 1993). As one of the central founding authors on business ecosystems, Moore was explicit that, in reality, company development is not linear, that is, he considered the model to be idealistic. As Moore was addressing business leaders, the challenge for company managers was to find a satisfactory route for navigating the interplay between cooperation and competition with other companies. The examples of business ecosystems that Moore (1993) drew on stemmed from the field of information technology—companies such as Intel, Microsoft and IBM. It is notable that although Moore (1993) saw companies as evolving, he did not theorize the concept of a ‘learning organization’, even though learning organizations were discussed intensively in research, as well as in adult education, in the 1990s.

Despite this business ecosystem concept’s early appearance in the 1990s, only a few references were made to business ecosystems per se until the concept’s utilization expanded during 2005–2010 (de Vasconcelos Gomes, Facin, Salerno, & Ikenami, 2018). Since Moore, other authors, such as Iansiti and Levien (2004), Adner (2006), and also Adner with Kapoor (2010), have been quoted regularly in the literature on business ecosystems (de Vasconcelos Gomes et al., 2018). As the concept of the business ecosystem gained popularity in the 2010s, it was simultaneously partially replaced by another ecosystem concept, that of the ‘innovation ecosystem’, considered to be a more advanced form of cooperation among business ecosystems.

In their review, de Vasconcelos Gomes, Facin, Salerno and Ikenami (2018) have reflected on how innovation ecosystems have become the new approach to studying and imagining strategies for combining entrepreneurship and innovation. The increased adoption of the ‘innovation ecosystem’ approach has not been unilinear: references to articles discussing business or innovation ecosystems were scarce until late 2007 (de Vasconcelos Gomes et al., 2018). Notably, the year 2007 coincides with the expansion of the ‘(digital) learning ecosystem’ concept, described next. According to de Vasconcelos Gomes and colleagues (2018), the main difference between the two concepts has been that the ‘business ecosystem’ approach is associated more with the strategy management domain. In contrast, the ‘innovation ecosystem’ approach has been associated with the creation of new forms of activities, such as value creation and new product development (de Vasconcelos Gomes et al., 2018). In sum, de Vasconcelos Gomes and colleagues (2018, p. 45) characterize the innovation ecosystem as a construct that aims to create value jointly or through co-creation,

that is, through interconnected and interdependent networked actors. These networked actors are a combination of customers, suppliers, innovators and other actors, such as regulators and local firms.

Technology-enhanced learning environments and digital learning ecosystems

The emergence of the expression ‘digital learning ecosystem’ is an outcome of the development of utilizing digital technologies for learning. From the perspective of planning and organizing learning programs, the utilization of digital technologies has meant significant cultural transformation. In the beginning, however, the technology-enhanced learning (TEL) environments were not referred to in terms of ecosystems. The first references to the new TEL learning opportunities as ‘digital learning ecosystems’ appeared in the mid-2000s. The expansion of the new term and approach can be observed by comparing its increased frequency in conference papers and published proceedings. In 2007, the annual International Conference on Digital Ecosystems and Technologies (DEST) was launched in Cairns, Australia. At the first DEST conference, Boley and Chang (2007) explored the meaning of the term ‘digital ecosystem’. Their aim was to define what the term means in contrast to natural, biological or social ecosystems. They suggested that digital ecosystems have three main characteristics, that is, digital ecosystems may: (a) overlap each other when several digital devices are available for use at the same time; (b) enable cross-system collaboration; and (c) remove geographic borders in a virtual sense. As such, digital ecosystems enable new formations of social ecosystems that utilize technology-enhanced learning (Boley & Chang, 2007).

The DEST conference series is one of many conferences and symposia through which interest in ecosystems has spread. For example, digital and technological ecosystems in relation to education have been the focus of the international Technological Ecosystems for Enhancing Multiculturality (TEEM) conference since 2013, and the parallel expansion of the diverse usage of the term ‘ecosystem’ in the context of learning research is visible in the conference proceedings of the European Conference on Technology-Enhanced Learning. The latter proceedings serve as a good database for obtaining an overview of the spreading of the new term across Europe as they have been published since 2006 (Nejdl & Tochtermann, 2006). Comparisons of these annual proceedings reveal an incremental increase in the interest in the concept of ‘learning ecosystems’. The term ‘learning ecosystem’ was not mentioned in the DEST conference proceedings in 2006–2007. In 2008, ‘ecosystem’ only appeared in a reference (Mishne & Glance, 2006; Petrushyna & Klamma, 2008). During 2010–2018, the terms ‘learning ecosystem’, ‘educational ecosystems’, ‘complex ecosystem’, and ‘ecosystems for learning’ have appeared in the papers of the conference series each year (Dillenbourg, 2008; Gruber et al., 2010; Kay & Kummerfeld, 2010; Millard & Howard, 2010).

By the late 2010s, researchers were providing more elaborate definitions of learning ecosystems. These definitions aimed to capture what digital learning ecosystems are in contrast to ‘traditional’ TEL environments (e.g., Aparacio, Bacao, & Oliveira, 2016; Gomez, Andersson, Park, Maw, Crook, & Orsmond, 2013; Dillenbourg, 2016; Kumar & Pande, 2017). Researchers have been largely in agreement that digital learning ecosystems typically: (a) enable combinations of various technological devices involving computers connected to the Internet; (b) are somewhat based on the alternation of distant learning via Internet-delivered content and pedagogical learning assignments both on- and offline; (c) involve

combinations of both individual and group learning (i.e., participation in learner groups of peers, learning guided by teachers, and individual self-directed learning utilizing available materials and devices are made possible). Overall, due to the numerous possible combinations of technological devices and pedagogical approaches, common agreement on a single overarching, dominant definition has not been realized. Also, the term 'learning ecosystem' has typically been described with various refined prefixes, such as digital, e-learning, blended, or personalized learning ecosystem. At the same time that studies on digital learning ecosystems became more numerous, research interest in business ecosystems and digital ecosystems also expanded.

As ecosystems of learning, business and innovation are all dependent on digital information communication systems and technologies, in the next section we present how their emergence was subsequent to earlier forms of theorizing organization and related to industrial revolutions.

From bureaucratic organization toward learning ecosystem

Next, we address the characteristics of Max Weber's classic 'bureaucratic organization' and then consider how the various forms of organization have evolved hand-in-hand with the four industrial revolutions.

Bureaucratic organization as described by Max Weber

Max Weber introduced his ideal type of bureaucracy (in *Wirtschaft und Gesellschaft*) at the beginning of the 20th century, and much of our understanding about organizations as social formations is still owed to his work. The organization that Weber observed at the time was the emerging public administration of a nation state. Since its introduction, his theory has become the classic organizational model used in the social sciences, and it has even been regarded as an ideal model for understanding other types of organizations, for example, volunteer organizations (Derlien, 1999).

The characteristics of an organization, according to Weber's model, are: division of labor and specialization of tasks, formal organizational structure, written rules to formalize and secure procedures within the organization, hierarchical decision making as well as communication and control, opportunities for employment and advancement based on performance, impersonalized modes of interaction with clientele and the public, and record-keeping. Furthermore, the private means of production were to be separated from public means for organization. The personnel in the bureaucracies had to have a professional education, disciplinary ethos, contract-based status, and were to receive salaries (Derlien, 1999).

Since Weber's time, the characteristics he perceived typical to the personnel of a bureaucratic organization have become generalized and rather taken for granted as the typical characteristics demanded of the workforce of modern private and public organizations. This enduring 20th century conceptualization provides interesting fuel for discussion concerning the relationship between learning institutions and work organizations. However, the theories of organization and institutionalization have been criticized for their shortcomings in explaining organizational or institutional change (Scott, 2001; Streeck & Thelen, 2005). In the developed societies, the increased shift toward employment in the service sector during the latter half of the 20th century, together with the development of modes of production, has also meant a shift toward more individualized and personal modes of service and work. At

the same time, there has been a shift in labor force requirements and in the demand for education and learning. The pace of the shift and its emphases have, however, been dependent on nationally dominant forms of production in each country as well as on the success of national education systems supporting the shift (Kozmetsky & Yue, 2005; Handel, 2012; Cedefop, 2018; Nedelkoska & Quintini, 2018).

In regard to how organizational practices have changed, the development of modern communications has been crucial for enabling the efficient exchange of information between geographically distant actors. The Weberian ideal bureaucratic organization aimed at stability and predictability. These were to be achieved by following the norms and codes of conduct as well as regulations given by authorities, such as government-appointed hierarchical bodies and representatives of nation states, and through the commitment of professionals to their work. In contrast, contemporary innovation ecosystems, business ecosystems, and learning ecosystems enable employees' flexibility and the development of new combinations and forms of production and service delivery. The new forms of organization have also demanded a transformation in the understanding of adult learning toward more flexible combinations of informal and formal education, involving self-directed and collaborative ongoing lifelong learning through various information and competence resources and professional as well as personal networks to keep up with the pace of change (Fenwick, 2006; Kang, 2007; Barnett, 2012; Evans, 2020; Nygren, Virolainen, Hämäläinen, & Rautopuro, 2020). At present, adults' learning demands career management-oriented building of a career where frequent job changes are expected along the way (Richardson, 2011; Barnes, Bimrose, Brown, Kettunen, & Vuorinen, 2020).

Next, we examine how new forms of communication have been adopted by organizations and, subsequently, by networks and learning ecosystems as well as business and innovation ecosystems in parallel with industrial revolutions, and how that adoption has enabled the modes of organization as adults' learning contexts to shift toward ecosystem-like constellations.

Industrial revolutions and the shift toward 'ecosystem' forms of organization

The adoption of industrial innovations has had large-scale effects on society and how the organizational contexts and opportunities for adult learning have transformed. Their central drivers and characteristics have been extensively studied, theorized and described by numerous scholars. For example, the changes caused in society by industrial revolutions, forms of production and employment have been described by 'long wave' theorists (Kondratieff, 1935; Schumpeter, 1939; Julkunen, 1987; Reischauer, 2018). The long wave approach focuses particularly on the effects that technological revolutions have had on the economic development of nation states. While our interest is focused more narrowly on organizational formations and their impact on adult learning, industrial revolutions are characterized as transformative contexts for learning and work; briefly discussed as follows.

Industrial revolutions have been characterized as unfolding in phases in which narrowly focused technological breakthroughs, in perhaps only one sector of the economy, spread through society (Tunzelmann, 2003). Firstly, old products, materials and processes become substituted with the introduction of new technologies. Thereafter, through incremental

change, the new products, areas of application, ways of processing, and their hybrid combinations emerge and become adopted by other sectors. Next, we provide a brief overview of the industrial revolutions, keeping in mind that their span and effects on society, the economy and employment overlap and consequently form a constantly evolving area of study (Tunzelmann, 2003; Reischauer, 2018; Nuvolari, 2019).

In the First Industrial Revolution, steam power and other innovations enabled the more efficient manufacturing of daily goods, such as through the use of the newly invented spinning jenny for fabrics, and the steam engine, which revolutionized transportation through the development of trains and steamboats (Tunzelmann, 2003). During the Second Industrial Revolution, electricity and oil transformed transportation further and the manufacture of steel and plastics was developed, enabling the design and industrial production of an entirely new range of daily goods. The industrial production of cars for more individualized transportation followed as a result (Snow, 2013), and new technological household goods and electrical appliances became a reality in ordinary homes. During the First and Second Industrial Revolution, elementary and secondary education systems were built to reach out to all of the population in many western societies, like in Nordic societies (Michelsen & Stenström, 2018). In contrast, the vocational education systems were established in even more diverse ways and reorganized to replace the apprenticeship training traditions that had dated back to pre-industrial times (Berner, Gonon, & Imdorf, 2015; Michelsen & Stenström, 2018). The exchange of information for learning at the times of the First and Second Industrial Revolution was predominantly based on writing and reading from printed books, which took place face to face and under the supervision of teachers at schools and master workshops in apprenticeships. As a result of the Third Industrial Revolution, the existing forms of vocational education and training had to be reformed to include the new information and communication technologies (ICT) (Eraut, 1989).

In the Third Industrial Revolution, the introduction of information and communication technologies based on microprocessors enabled faster transportation as well as vast storage of knowledge and information through the widespread use of personal computers and mobile phones (Castells, 1997). For learning, this meant that the exchange of printed material and information became more effective and faster, and television and computing could be utilized to deliver materials for learners (Padolina, 1997). There were more alternatives for organizing distant learning. The Fourth Industrial Revolution (Industry 4.0, also referred to as Manufacturing 4.0), in turn, has been characterized by the development of cyber-physical systems that are capable of collecting and interpreting data, communicating in their operative environment, exchanging information, and regulating themselves (i.e., not merely reacting to signals but also reorienting their operations) (Goertzel, 2014; Reischauer, 2018). In addition, the interconnection of smart devices via the Internet (Internet of Things, IoT), storage of information in so-called cloud services, cloud computing and cloud architectures have enabled new forms of engineering, goods and services, material flow (e.g., remote 3D printing), and supply chain management (Heikkinen 2018; Müller, Bolica, & Voigt, 2018). In regard to learning, the Fourth Industrial Revolution has enabled the building of digital ecosystems of learning (El-Hussein & Cronjé, 2010; Kumar & Pande, 2017; Brauer, Korhonen, & Siklander, 2019).

In Table 1, we summarize how these industrial revolutions have taken place in parallel with the introduction of new organizational forms. While Table 1 presents each period as a

separate row, we agree with previous researchers of economic long waves and industrial revolutions that the adoption of new technologies and new forms of organization has taken place in parallel with the continued use of earlier technologies. It is therefore important to underline that the adoption of innovations and new forms of production and management has not been unilinear but rather dependent on the alignment of resources and actors regionally, as well as on social approval for new formations (Tunzelmann, 2003; Kim, 2018; Reischauer, 2018). In addition, old forms of organization have prevailed as coexistent layers and continue to influence activities within organizations. The adoption of new forms of organization across sectors of production has been dependent on their context and the opportunities for financing change, and they have been implemented at a different pace in different countries and regions. In Table 1, the new emergent forms of organizational relations are presented as ideal types in order to offer a heuristic model; they are therefore not to be taken as a normative guide for better or more effective organization.

_____Table 1 (send in separate file) to be placed here_____

Toward an increased understanding of the new complexities of education–work relations in the landscape of ecosystems

In this chapter, thus far, we have presented an overview of how the concepts of digital learning ecosystems, innovation ecosystems and business ecosystems have emerged. We further showed how these were preceded by the concepts of learning organizations, learning regions, university–government relations and national innovation systems, as well as by networks and the actor–network theory. Our aim has been to outline how these concepts address the new forms of organization that take advantage of digital technology and redefine the context for adult learning. We argued that the adoption of innovative technologies for the interaction, exchange and storage of knowledge and information has enabled the new conceptions of organization that represent turning points in the industrial revolutions (see Table 1). As the latest industrial revolution, Manufacturing 4.0, has involved taking advantage of machine learning, artificial intelligence, cloud services and the Internet of Things; it has changed the practices for information sharing and storage in unforeseen ways (Atzori, Iera, & Morabito, 2010). In everyday practices, this has taken place through, for example, the utilization of collaborative robots, so-called 'cobots', for service production. We conclude by pointing out the demand for new research and understanding that these changes bring.

Toward the end of the 20th century, the adoption of digital technology has enabled planning more in-depth adult learning and connecting the best expertise with the help of technology, but their utilization needs to be elaborated in order to truly benefit from its opportunities (Harteis, Gruber, & Hertramp, 2010). Examples of joint platforms for providing study modules and study programs already exist (e.g., Campusonline.fi, n.d.). Schools, learning programs, apprenticeships and work-based learning are no longer geographically bound to one place, and work-related learning can be organized in a variety of new ways (e.g., El-Hussein & Cronjé, 2010; Kumar & Pande, 2017).

The adoption of new technologies has meant that adult learners need to identify and re-evaluate their skills as well as gaps in these, and they need to plan their learning across the landscape of ecosystems. To be able to flourish and succeed in this challenge, learners also need the right career management skills (Hooley, Shepherd, & Dodd, 2015; Barnes et al., 2020). They need to learn to operate in and differentiate between ecosystems on various levels, that is, whether they are purely technical, (digital) ecosystems targeting specific tasks for learning or the production of services, or whether they are more strategic and managerial in nature, like in business and innovation ecosystems. They need new skills, not only to utilize the new technologies but also to meet security issues related to data protection when handling confidential information and data between institutions. Companies, for their part, should offer opportunities for sustainable learning amidst turbulent changes (Lemmetty & Collin, 2020). In planning adult education, there is a particular need to pay attention to a potential polarization and differentiation between learner groups, as well as to those groups of learners who might drop out of training opportunities designed to teach the utilization of new technologies and other competencies demanded in collaborative relations.

Research has shown that adult learners' technological literacy and problem-solving skills vary considerably depending on their age, hobbies and former education (Eynon & Helsper, 2010; Hämäläinen, De Wever, Nissinen, & Cincinnato, 2017). Due to the shift toward a

landscape of overlapping ecosystems, learners who have had less access to training for new digital technologies are likely to need more support when moving from one learning and work context to another. At the same time, there is a growing need for the recognition of both prior learning and learning outside of study programs, as well as for the acknowledgement of the diversity of learners. New forms of accrediting digital and other learning need to be developed. In this regard, the provision of micro-credentials through short, low-cost online courses and related online certification has been suggested to meet the diverse learning needs that have to be acknowledged by both employees and employers (Brauer, Korhonen, & Siklander, 2019). The need to acknowledge combinations of formal, informal, and non-formal learning has been intensified (OECD, 2019). In higher education, a model *life-wide curriculum* involving the university ecosystem and combining the academic curriculum with the co-curriculum, extra-curriculum and work-related curriculum has already been suggested (Jackson, 2020).

Since multi-professional communities are organized to work from a distance and via digital platforms, the demand for coordination and communication increases. The importance of ethics concerning the utilization of such new technologies has been underscored (Berkowitz & Miller, 2018). The use of technologies across institutional boundaries increases expectations for collaboration, confidence and management between expert communities, and it sets new demands for individual integrity.

In conclusion, we want to underscore that the models describing ‘learning–work relations’ in the new context of the Fourth Industrial Revolution (Manufacturing 4.0) are still unfolding. In particular, in regard to the differing scales of ecosystems, there is a need to distinguish between small-scale ecosystems connecting one to three actors as compared to large-scale ecosystems connecting hundreds of actors and nodes. Research is needed to better understand how related governance and orchestration is being transformed, that is, what kind of relevant governance and self-organization is taking place at the macro, intermediate and individual levels (Evans, 2020).

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Table 1. *The Co-Evolution of Technology and Organizational Arrangements Toward Innovative Learning Ecosystems*

Approximate time period of origin	**Development and emergence of new forms of industry and production**	**Organizational relations and means of communication, storage of information**
18th century until early 19th century (1750–1815)[1]	**1st Industrial Revolution**: Expansion of new innovations such as the steam engine, industrial production, railways, and the replacement of handicraft professions	**Emergence of the (pre-Weberian) bureaucratic organization:** Connected by traditional mail and personal contact; organization of better bookkeeping for census and tax collection by nation states in their initial forms.
Turn of the 20th century (1870–1914)[1]	**2nd Industrial Revolution**: Electricity, automobiles, chemical industries	**Expansion and development of the bureaucratic organization:** Departments connected by faster transportation of traditional mail; expanding communication by telegraph and telephone; generalization of typewriters and paper documentation; increased dissemination of printed information.
Turn of the 21st century (1973–2005)[2]	**3rd Industrial Revolution**: Consumerism, information technologies, popularization of computers, microchip development	**Learning organization and networks between organizations**: Expanded use of computers for information storage and communication between organizations; organizational subdivisions enhanced by the Internet, e-mail and mobile phones. Development of memory storage devices brings a substantial shift away from printed material and earlier storage forms like CD-ROM to smaller, easily portable devices like memory sticks and remotely accessible webpages; increased and faster 'just-in-time' information exchange.
Early 21st century (2006–Present)[2]	**4th Industrial Revolution**: Industry 4.0 (or Manufacturing 4.0), machine learning, artificial intelligence, cloud services, cloud architectures, Internet of Things	**Business and innovation ecosystems, digital learning ecosystems** Communication via mobile devices and expanded use of software applications and digital platforms enable better participation and interaction between people across distances. Use of computers, information technology devices and the Internet is further increased and enhanced by cloud storage services, big data collection, and the emergence of adjustable production control processes aided by artificial intelligence, sensors and bots.

Note:[1] Time spans for Industrial Revolutions 1–2 suggested by Tunzelmann (2003). [2] Time span is suggested by authors based on published studies cited in this chapter. It should be noted that the pace of adopting new technology varies substantially between regions, organizations and individuals.