World Wide Web (2015) 18:1177–1197
DOI 10.1007/s11280-014-0305-1

Service economy, knowledge, and the need for T-shaped innovators

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Received: 28 October 2013 / Revised: 3 April 2014 /
Accepted: 15 July 2014 / Published online: 15 August 2014

Abstract The paper is rooted in the recent Service Science line of research focused on the notion of 'T-shaped' knowledge. To the aim of theoretically and conceptually discuss the knowledge endowment required to a 'T-shaped' innovator, focus is on the notion of dynamic capabilities as characterizing the human side of service innovation. After a short introduction (Section 1), a model of the affirmation of the knowledge economy and the emergence of the consequent need for T-shaped innovators according to an escalation framework is presented (Section 2). Then, on the basis of the interpretation of T-shaped knowledge developed by adopting a Viable Systems Approach (*VSA*) perspective, conceptual links between the notions of incremental and radical innovation, on the one hand, and of capabilities and competences, on the other hand, are explored (Section 3). The paper findings provide a taxonomy of T-shaped innovators' capabilities that turn out to be more and more crucial to develop innovation in a context of growing complexity (Section 4). Finally, it moves on to discuss the organizational and technological aspects of management of T-shaped innovators (Section 5), outlining some managerial implications and future research paths (Section 6).

Keywords Service economy · Knowledge · T-shaped · Viable Systems Approach · Dynamic capabilities · Competences · Distributed technologies

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1 Introduction

The current socio-economic scenario is characterized by an increasing relevance of *service* as the fundamental basis of market exchange, and *knowledge* as the key driver of innovation. The strong relationship between service and knowledge is effectively captured in the Service-Dominant Logic (SDL) definition of service as the application of competences (such as knowledge and skills) by one party for the benefit of another [68], which suggests that knowledge is fundamental to enable service innovation.

In the service economy, any organization can be viewed as a service system−i.e. a structured configuration of people, technology and shared information−that interacts with other service systems to co-create value [49].

The key resource of service systems is knowledge.

Knowledge has always played a leading role in economic and social development and in innovation processes. Scientific, technical, and organizational knowledge has been exchanged throughout the world according to a movement of constant diffusion [21] whose scope and speed depend on social processes, such as learning by doing, learning by using, learning by observing, learning by cooperating, and learning by interacting, and by available communication technologies. Every age has seen the birth of organizations and institutions in which new forms of archiving, teaching, learning, and knowledge development are experienced and established [22]: from the Academy of Athens, founded in 387 B.C. by Plato for the training of young Athenians and foreigners of good families to the institution in modern nation-states of a public education system that is free and guaranteed to all citizens; from Cistercian abbeys, which formed a powerful network for the transmission of technical knowledge in the Middle Ages to the Open Source community, in which the knowledge that circulates freely through the network of relationships is a form of social capital and a productive resource available to members of a community and in which mutual aid, solidarity, competence, and reputation are unquestionable values [34, 35]. The emergence of ways of trading and exchanging knowledge and the development of legal instruments, such as intellectual property rights, to allow the economic exploitation of this knowledge, are key chapters in the history of capitalism. However, since the second half of the twentieth century, what distinguishes advanced economies is their relationship with knowledge and the subsequent capability of innovation. An intense relationship exists in which knowledge and those who generate it are the key resources and the main sources of competitive advantage of the economic system itself and its socio-economic actors. This relationship runs so deep that expressions such as ‘knowledge-based society’ and ‘knowledge economy’ have entered common usage [33].

The exchange of knowledge is fundamental to produce innovation in the service economy. It allows multi-disciplinary debate and co-creation processes necessary to develop a trans-disciplinary *science* of service systems, as pursued by the Service Science Management and Engineering (SSME) community [48, 63]. In this context, an increasing need to move across different disciplines and systems is questioning current higher education programs which are still producing ‘I-shaped’ graduates, i.e. students with deep disciplinary knowledge, while a need for ‘T-shaped’ professionals has been widely recognized in the last decade [42, 43, 62, 63].

A T-shaped professional is endowed with both ‘vertical’ competences in specific disciplines/systems, and ‘horizontal’ capabilities to deal with different problematic contexts effectively addressing change [15, 17]. People that have deep disciplinary knowledge in at least one area, and understanding of systems, as well as the ability “to function as ‘adaptive innovators’ and cross the boundaries between disciplines”, characterize the profile of a ‘T-shaped innovator’.

The boundaries-crossing required to develop effective innovation in a fast changing environment, is significantly supported by ICT (Information and Communication Technologies), especially thank to the arise of distributed technologies and the evolution from Web 1.0 to Web 2.0. By allowing interaction between different minded and skilled users in an open source environment [52], the Web 2.0 is a powerful set of info-communication technologies enabling innovation based on knowledge exchange, sharing and recombination.

ICT is fundamental to support the development of successful innovation in service systems [24]. It should be reminded, however, that "a mediocre technology pursued within a great business model may be more valuable that a great technology exploited via a mediocre business model" [24: 354]. Agreeing with this view, we believe that it is always through an effective business model that service systems' innovation becomes valuable for a market and it is the human resources' capabilities that possess the innovation potential. Conversely, technology and organization should create the conditions for this potential to be unlocked and developed.

Accordingly, our research questions are: *What kind of human skills are required to pursue effective innovation in the service economy*? *What are the organizational and technological conditions that allow the human resources' innovation potential to be enabled?*

With the purpose of deepening the study of the human resources' knowledge endowment necessary to develop effective innovation in the service economy by crossing boundaries between disciplines, i.e. to be a successful T-shaped innovator, our aim is to theoretically and conceptually discuss the notion of 'T-shaped' knowledge at individual and organizational level. Our conceptual and theoretical discussion aims at fostering multi-perspective debate and knowledge exchange among scholars as well as practitioners from diverse disciplinary domains and professional sectors. In particular, we believe that a bridge between the management and engineering scientific domains should be built to address the challenges of innovation in the service economy.

Our study, which proposes the interpretative contribution of the business scholars' perspective, is organized as follows: we first model the driving forces that have led to the development of the knowledge economy and the related need for T-shaped innovators according to an escalation framework (Section 2). Subsequently, we propose an interpretation of T-shaped knowledge from a Viable Systems Approach (*VSA*) perspective built upon the notions of capabilities and competences [4, 6, 11, 17, 39, 41, 65] (Section 3). Then, an attempt is made to identify the taxonomic T-shaped skills crucial to produce innovation in the service economy (Section 4). At organizational level, an effective management of T-shaped innovators requires a deep change in the selection and design of organizational variables: Section 5 focuses on organizational mechanisms and info-communication technology infrastructure. The paper ends with an indication of some managerial and practical implications and future research paths (Section 6).

2 The rise of the knowledge economy and the emerging need for T-shaped innovators

By adopting an approach based on circles of causality, the emergence of the knowledge economy can be explained based on the thrust of two self-reinforcing factors: on the one hand, the increase in long-term resources dedicated to knowledge exploration, learning, and sharing (education, training, R&D, economic coordination); on the other hand, the revolution in ICT that directly affects the processes of knowledge exploration, exploitation, and sharing and that enhances and produces innovations in the socio-technological context in which these processes are conducted [20: 3, 23: 76–79; [31: 174]. What are the features that make the

knowledge economy a new socio-economic paradigm? The knowledge economy involves the following aspects: a significant share of employment in knowledge-intensive work that is significantly higher than in the past; the crucial and growing economic weight of high-technology sectors (IT, telecommunications, electronics, aerospace, biotechnology, pharmaceuticals, advanced materials); and investment in intangible capital that is higher than the investment in physical capital in the majority of productive activities. From a perspective that is more closely related to competitive dynamics, the knowledge economy is characterized by the following processes: a) the dematerialization of the value chain; b) the globalization of the competitive arena; c) technological convergence; and d) the search for economic flexibility, creativity, and knowledge integration [60].

a) In the knowledge economy, the factors that determine a firm's success increasingly depend on the firm's ability to extract value from knowledge resources rather than physical resources. Thus, the share of added value that comes from intangibles (R&D, design, product customization, customer care) is larger than the share from tangible aspects. Physical capital is certainly not supplanted by immaterial capital, but it is less crucial for the survival of the company and less strategic for the purposes of superior profitability compared to the company's competitors. The growing centrality of knowledge requires a rethinking of the composition of productive capital. The knowledge economy calls for the downsizing of material slack, which is a source of inefficiency, in light of the need for intangible slack, which is a source of cognitive flexibility.
b) The enhancement of the value chain rings occurs in an increasingly global economy. The competitive arenas are no longer circumscribed as restricted geographical areas. Competition occurs on a global checkerboard and at a global scale. The challenge is to fit into long nets that govern strategic networks that are no longer self-contained in a well-defined and circumscribed geographical region but are territorially extended and open upstream and downstream in geographic terms.
c) A third feature of the knowledge economy is the blurring of industries' boundaries. Knowledge capitalism is characterized by a process of increasing hybridization between industries due to the spread of adaptive, multitasking, and transverse technologies, such as optics, electronics, information technology, telecommunications, advanced materials, and biotechnology. Knowledge relevant to a sector comes from 'afar', from other sectors. Antecedents and distinct technological trajectories become highly integrated and interdependent, and the technological convergence process becomes more evident [67: 15].
d) The knowledge economy does not deny the importance of economies of scale, which are a cornerstone of competitiveness in many areas. However, in addition to these, it sees the growing importance of economies of flexibility and creativity and economies of knowledge integration as key conditions for innovation under conditions of high environmental complexity [9].

Hence, there is a growing importance of flexibility based on intangible assets, particularly flexibility gained by leveraging slack linked to creativity, the abilities of problem setting and problem solving, and human resource experience, all of which are elements of intangible slack [20, 56]. Creativity, discontinuity, serendipity, and analogical thinking thus become the keystones to innovate processes, products, strategies, and organizational models.

Because of these competitive dynamics, the knowledge economy requires all economic actors to develop a set of competences and dynamic capabilities to complete a 'T-shaped knowledge' configuration, which, as mentioned, includes both vertical competences (I-shaped competences) (i.e., technological, industrial specialization) and 'horizontal

capabilities' [15, 17]. The latter expression refers to boundary-crossing capacities *latu sensu*, or capabilities that allow or strongly support connections/links of various kinds [14]: links between heterogeneous specialized knowledge (vertical knowledge); links between problems requiring solutions and solutions in need of problems; and links between people who have different cognitive frames because they live or work separated by geographical, organizational, hierarchical, or cultural boundaries. That is, it involves 'bridge capabilities', which play a crucial *synapse role* in continuous learning and innovation, which are the key processes for survival.

Innovation is not *absolute new* knowledge. Innovation (of products, processes, managerial practices, and strategic vision) often springs from a new way of linking and recombining extant knowledge. Inventing and innovating involve the capability of coupling fragments of 'old' knowledge in different, original, new ways—knowledge that is stored in the collective memory and in the enormous, fascinating knowledge endowment accumulated throughout human history (scientific knowledge, traditional knowledge, natural language). For these characteristics, the synapse capabilities are critical to increase the survival of an organization in conditions of complexity. They enrich organizations with the necessary variety [13], and they expand the space of possible alternatives (competitive or cooperative; strategic or organizational; short- or long-term perspectives). They allow the individuals, groups, and organizations that possess them to generate connections and to explore and exploit additional knowledge. Thus, synapse capabilities enrich the number of options available to an organization, maintaining or improving its ability to survive [41].

In a rubbery landscape, organizations compete with other as systemic entities by building competitive advantage, not through the control of resources but through the development of new combinations of competences that are firm-specific and, consequently, inimitable. In rapidly changing contexts, the mechanisms of the formation of competitive advantage are re-interpreted on the basis of the development of new *competences* through a structured process of combining and recombining basic capabilities. This process is embedded in the operative structure of the firm and guided by decision makers endowed with appropriate *dynamic capabilities* [17, 65]. In turn, the emerging need for T-shaped innovators (Figure 1) leads to the need for T-shaped human resources (especially managers and professionals) [11].

Thus, to identify the knowledge endowment necessary to develop T-shaped innovators, in the next section, we will elaborate upon the concept of T-shaped knowledge on the basis of the conceptual distinction between the notions of capabilities and competences.

3 From competences back to capabilities: the key to developing T-shaped knowledge

3.1 The distinction between capabilities and competences from a *VSA* perspective

By focusing on the human side of organizations as service systems, scholars, academics, and researchers wonder how to rethink approaches and training programs to equip managers and professionals with the appropriate skills to cope with a changed and changing reality by developing effective innovation. The era of specialization and the technological progress have produced highly skilled human resources which are, however, increasingly incapable of addressing decisions that go beyond familiar problem solving because the models they possess are inadequate to support an understanding of the emerging and changing needs.

The *Viable Systems Approach* (*VSA*) research stream studies change management and innovation through the lens of systems thinking [4, 7, 8, 10–12, 16, 17, 39–41]. The *VSA* is a research and governance methodology rooted in system theory [70] and developed on the basis of an updated version of the Viable System Model of Stafford Beer [19]. A fundamental

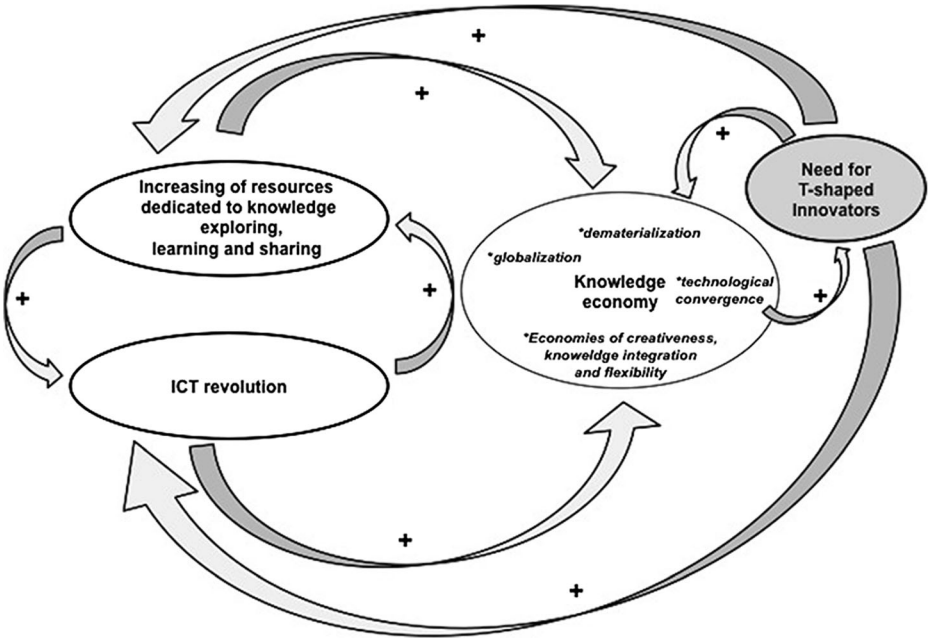

Figure 1 The emerging need for T-shaped innovators: an escalation feedback model. Source: Our elaboration, www.asvsa.org. Figure used with permission from ASVSA

research area of *VSA* investigates the conditions of survival and viability of business as well as social organizations in a changing environment [57].

According to the *VSA*, a viable system is a system which evolves in order to survive by accomplishing an ongoing learning process through which it becomes more effective in its environment [41]. Both individuals and organizations can be viewed as viable systems. A system remains viable in its environment as long as it is capable of setting, pursing and achieving its goals by establishing harmonic (consonant) relationships with other viable entities in order to co-create mutual value [54, 69]. Information and knowledge are key resources that allow viable systems to accomplish the learning processes necessary to develop adequate capabilities and competences to pursue innovation in a changing environment.

The *capabilities* are "complex bundles of skills and collective learning, exercised through organizational processes that ensure superior coordination of functional activities" [26: 40]. A *competence*, instead, is "a unique mix of knowledge, skills and technologies leading the generation of a series of profitable innovations." [25: 295]. To develop such a unique mix, *organizational capabilities* are required as "the capabilities of an enterprise to organize, manage, coordinate, or govern sets of activities" [30: 290].

Teece, Pisano and Shuen refer to *dynamic capabilities* "as the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments" [65: 516]. "The term 'dynamic' refers to the capacity to renew competences so as to achieve congruence with the changing business environment; […]. The term 'capabilities' emphasizes the key role of strategic management in appropriately adapting, integrating, and reconfiguring internal and external organizational skills, resources, and functional competences to match the requirements of a changing environment" [65: 515]. By building upon the definition of dynamic capabilities by Teece, Pisano and Shuen, the *VSA* provides a model which

integrates the notions of capabilities and competences and is useful to investigate the viable system's knowledge endowment as an *information variety*, and knowledge exchange among viable systems as a 'learning by interaction' process. The viable system's *information variety* is made up of information units, schemes of synthesis, general schemes and categorical values [6]. In this multi-dimensional model [5, 7], *information units* represent the data possessed by the system and exchanged during interaction. The *schemes of synthesis* represent structured and contextualized knowledge, which qualifies the system's set of *competences*. The *general schemes* represent the system's cognitive schemes, i.e. the essential cognitive frames which act like 'sieves' through which incoming information units are filtered during interaction, so that only selected items are processed and contribute to the variation of initial variety. The general schemes qualify *the knowledge dynamic capabilities of the system,* i.e. *the knowledge potential which allows the system to produce new knowledge in the form of new schemes of synthesis when facing a new problematic context*. The *categorical values* represent the set of values, strong beliefs, convictions, etc. that direct the system's choices and behaviors in any problematic context, qualifying its unique identity. The development of the information variety model is grounded in relevant literature contributions which span across multiple disciplines (see [5]).

In a changing environment, viable systems are required to be flexible and to develop successful innovation by dynamically meeting evolving requirements. Depending on the kind of change to address, *incremental* or *radical* innovation is pursued. Incremental innovation implies "improvements within a given frame of solutions ("doing better what we already do")"; conversely, radical innovation implies "a change of frame ("doing what we did not do before")" [53: 82]. According to Henderson and Clark "incremental innovation reinforces the capabilities of established organizations, while radical innovation forces them to ask a new set of questions, to draw on new technical and commercial skills, and to employ new problem-solving approaches" [44: 9]. Addressing the change through radical innovation implies the exploration of the 'new', i.e. the 'unknown', which means to go beyond current competences, moving up to capabilities. In *VSA* terms: incremental innovation is developed within *current* schemes of synthesis that is by improving current ways to solve specific problems; radical innovation implies the development of *new* schemes of synthesis that is the finding of new ways to solve problems; this capability is enabled by the general schemes. An example of incremental innovation is the superstore as a new retail formula developed within existing retailing 'scheme': it is a more effective and efficient way to retail goods compared to previous ones. The best example of radical innovation, from which many incremental innovations have been developed, is the Internet. By applying the Internet innovation to the case of retail, a *new* retailing 'scheme' has been developed that is the 'e-tailing'.

In *VSA* terms, then, we would say that it is the higher order cognition enabled by the general schemes that allows effective combination and re-combination of existing schemes of synthesis, thus developing new ones and renewing the system's competences endowment. It is in this sense that the traditional dilemma exploration/exploitation appears solved [50]: the exploration of the unknown is accomplished through the exploitation of the known. In this relationship between the known and the unknown lies, in our view, the relevance of the distinction between dynamic capabilities and competences: when dealing with a changing scenario where current schemes appear no longer useful, the exploration of the unknown is required and the dynamic capabilities assume a strategic relevance. Competences, as expression of schemes of synthesis, deal with the known, and find a great support in technology to which they are strongly related; dynamic capabilities, as expression of general schemes, deal with the unknown. In this sense, we hold that the former act in the realm of incremental innovation, while the latter fuel more radical innovation.

A representation of the relationship between all the discussed concepts is proposed in Figure 2.

Innovation needed to solve simple or at most complicated problems, belongs to the technical and technological realm of the known and only requires an appropriate knowledge endowment. This kind of innovation implies unchanged competences, in the case of simple problems, and hyper-specialization of competences, in the case of complicated problems [15].

Instead, when existing competences are not useful to face emerging problems, the unknown needs to be addressed and a shift to capabilities is required to activate a new process of knowledge creation by creatively combining and re-combining existing resources. In this process, the action of the general schemes is fundamental. As we will illustrate in Section 4, general level capabilities, such as *wishful thinking, lateral thinking, open-minded gifts, knowledge-seeking,* and *social intelligence*, qualify the endowment necessary to develop the horizontal 'bar' of a T-shaped innovator. The horizontal bar of a T-shaped innovator is where the potentialities linked to his/her talent lie. The concrete expression of this talent is in the competences developed with reference to specific problematic contexts.

The conceptual links between the notions of radical/incremental innovation and those of capabilities/competences help to clarify the system's cognitive mechanisms behind innovation. Here the interpretative contribution of the *VSA* distinction between general schemes and schemes of synthesis comes to the fore enabling the understanding of the causal relationship between capabilities and competences and, therefore, between radical and incremental innovation, highlighting relevant conceptual and practical aspects that should be considered in the definition of the knowledge endowment of T-shaped innovators.

3.2 The role of (dynamic) capabilities in the developing of T-shaped knowledge

In the basic representation of T-shaped professionals, the vertical bars represent the disciplinary specialization and the deep understanding of one system and are characterized by 'analytic thinking' and 'problem solving' competences. However, what is crucial to innovation is the horizontal bar, which is represented as qualifying the ability to collaborate across a variety of different disciplines thanks to capabilities of 'critical thinking, communications, perspective, global thinking, project management, network' [45, 61, 63].

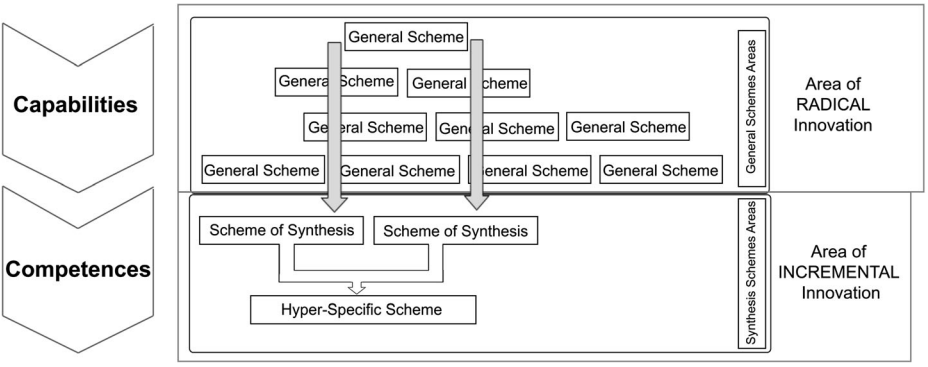

Figure 2 The role of capabilities and competences in radical and incremental innovation. Source: Adapted from [15: 276, www.asvsa.org. Figure used with permission from ASVSA

Our aim is to go behind these capabilities in search for the 'keys' to develop them. In other words, we intend to identify the (knowledge) potentialities that make people capable of effectively innovate, facing change, etc. by moving across different disciplines, context, systems etc.

In a previous work, we expanded the 'T-shape' notion by shifting from the individual to the organizational and inter-organizational levels of analysis, with the aim of extracting a more general representation of T-shaped knowledge to qualify any entity's knowledge endowment necessary to complete the 'T'. By considering the case of what we called *Open* Communities of Practice, we focused on the knowledge exchange in a distributed knowledge management network to discuss the technological and organizational conditions necessary to develop the horizontal bar of the 'T' starting from existing ('I-shaped') vertical bars [17].

As illustrated above, our theoretical assumptions allow us to generalize the notion of 'T-shaped knowledge through the information variety model. The emerging view leads us to represent the T-shape as a combination of breadth and depth in which the discussed distinction between capabilities and competences helps us to re-interpret the notion of T-shaped professionals. The result of this re-interpretation is illustrated in Figure 3, in which we emphasize the relevance of dynamic capabilities in the developing of the 'horizontal' part of the investigated knowledge endowment.

When represented through the information variety model, the knowledge endowment of an 'I' compared to a 'T' shape, appears as characterized by a weak weight of the general scheme dimension and a strong weight of the scheme of synthesis and information units dimensions. Differently, the 'T' shape is characterized by a high weight of the general schemes combined with a high weight of schemes of synthesis and information units relatively to specific problematic contexts (disciplines/systems) [17: 51].

It derives that the building of the horizontal bar implies the enrichment of the system's general schemes endowment. When activated, these general schemes dynamically enable the system to move across different contexts. This repeated 'movement' through a cross-boundary interaction [72] over time builds a 'bridge' between two or more vertical bars, developing and

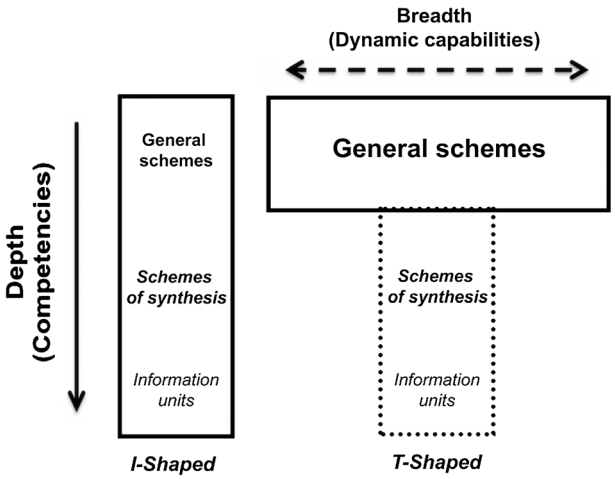

Figure 3 The "T-shaped" knowledge from the *VSA* perspective. Source: [17]: 51, [10]: 166, www.asvsa.org. Figure used with permission of ASVSA

reinforcing the horizontal bar, as illustrated in Figure 4 [11]. What interestingly emerges from our representation is that:

- The knowledge exchange between I-shaped individuals with deep knowledge in different disciplines/systems which configures a cross-boundary interaction, forces to activate general schemes in order to make reciprocal understanding possible. This "disposition for collaboration" across disciplines is composed of two elements [43]: first, empathy, which is important because it allows people to imagine the problem from another perspective; second, enthusiasm about other people's disciplines "to the point that they may actually start to practice them" [43].
- The interaction between cognitively distant [52] individuals is expected to be difficult if not unsuccessful. What allows effective interaction in these cases, are the categorical values: they qualify the dominant cultural orientation of individuals, which, in turn, influences their attitudes and behaviors and is responsible for accepting or refusing interaction depending on the perceived degree of consonance (relational harmony) between interacting entities. Thus, the categorical values are fundamental to enable knowledge exchange.

In the following section, we propose a possible taxonomy of T-shaped innovators' skills by focusing on the horizontal capabilities as the critical 'area' to develop T-shaped innovators.

4 Toward a taxonomy of T-shaped innovators' key capabilities

If we accept, as suggested by *VSA*, the distinction between the horizontal and vertical bars of the T in terms of capabilities/competences, focusing on the key elements that form the horizontal bar, our next step is to develop a taxonomy through which we can represent its 'contents' in terms of dynamic capabilities, i.e. capabilities useful to face change in a context of increasing variety and variability. Once these main 'contents' have been identified, possible pathways for re-thinking education programs as well as organizations' knowledge management approaches can be outlined.

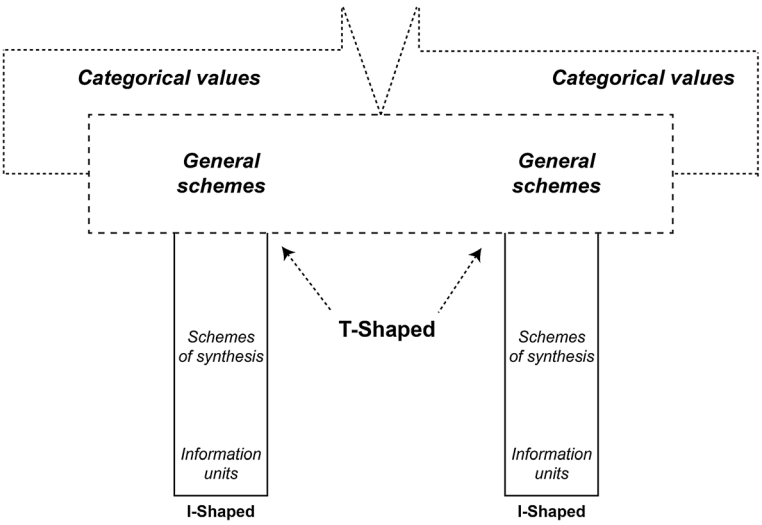

Figure 4 From I- to T-shaped knowledge through the building of the horizontal bar. Source: [17], www.asvsa.org. Figure used the permission of ASVSA

Rooted in the psychological and cognitive mechanism literature and on organizational behavior, this section presents a psycho-cognitive interpretation of the T-shaped concept to deepen our interpretation of T-shaped knowledge. By shifting focus from the technical and technological competences of innovation to the human capabilities of change management, we highlight the criticality of the horizontal bar of the T. This focus on the human side of innovation leads us to consider the psycho-cognitive mechanisms that allow, facilitate, or support the 'connection processes' (connections among ideas, knowledge, people, cultures, organizations, and countries) that enable the development of the horizontal bar.

Accordingly, we attempt to identify the 'synapses' capabilities that play a crucial role in linking heterogeneous ideas, matching solutions searching for problems and vice versa, know-how trading and knowledge brokering and sharing, and creating good socio-emotional conditions to promote these processes. These capabilities involve bridge capabilities that sustain an endless knowledge flow within and among teams and organizations, a flow that is increasingly viable for the effectiveness of the innovation process.

Differences in the bridging capabilities of human resources may play different roles in organizational effectiveness; firms that are best in their class in innovation have the best bridging capabilities (Figure 5). Therefore, it is important to identify bridge capabilities and how they work. Accordingly, we describe five horizontal capabilities that, from our perspective, characterize a T-shaped innovator and that are useful to successfully deal with change: *wishful thinking, lateral thinking, open-minded gifts, knowledge-seeking capabilities,* and *social intelligence*. Although it is not possible to establish this in an univocal way, we could argue that the first four capabilities are related to cognitive mechanisms that bridge and recombine ideas and knowledge in new ways. These are mechanisms that are closely related

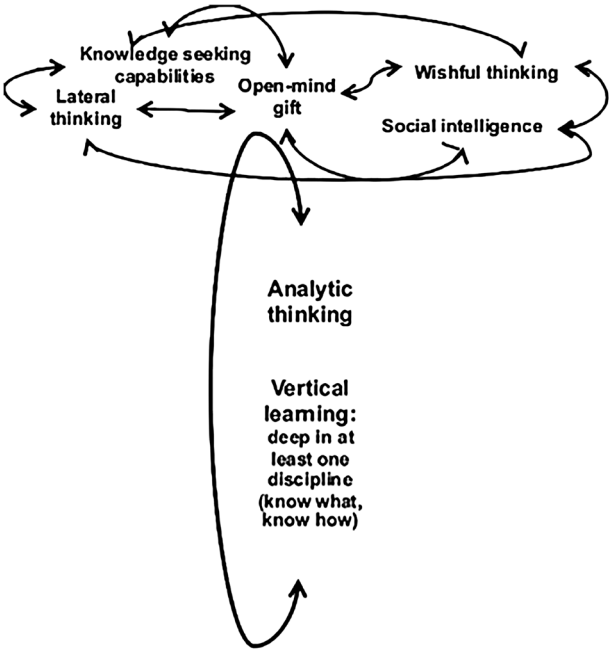

Figure 5 The individual's T-shaped knowledge set. Source: Our elaboration, www.asvsa.org. Figure used with permission of ASVSA

to creative and innovative acts. The latter (social intelligence) is a gift that connects people in a way that promotes consonance and resonance in social contexts (in family, at school, at work).

Wishful thinking It involves the reciprocal relationship between wishes and opportunity. In Aesop's tale, the fox that does not succeed at picking the grapes convinces itself that the grapes are unripe. In this tale, wishes adapt themselves to opportunities. However, there are other types of cognitive mechanisms in the relationship between wishes and opportunities. One is relevant to shedding light on the horizontal dimension of the T-shaped set: *wishful thinking,* a thought able to wish, a thought that emerges from a wish and creates a new opportunity, a thought that is the seed for any act of creation or innovative idea [2: 49] and is capable of triggering new future scenarios driven by a syntropic force [47].

Lateral thinking It is the realm in which problem creation and problem solving are addressed according to an analogical approach: new ideas originate from re-combinations of extant ideas through the original, unusual, and unlikely matching of knowledge belonging to multidisciplinary fields. For these reasons, lateral thought involves re-combining and re-setting. It is recombining in the sense that when it works, it attempts to re-shape a consolidated model, putting together the same elements and the same ingredients in new ways to obtain new models or original recipes. Insofar as it is a re-combination, it is a re-setting because the usual thought trajectory is diverted and the individual cognitive and behavioral frames change [27, 28, 71].

Open-minded gift The gift of new experiences and the curiosity for what is new join with the capacity to look at the same phenomenon through different glasses and from different perspectives, with relatively flexible cognitive frames in an anti-conformist way. An open-mind person likes exploring unknown phenomenon, does not avoid unfamiliar situations, and has heterogeneous interests [18, 36].

Knowledge-seeking capabilities It refers to the capacity to obtain access to data, information, and knowledge. It is of primary importance in bridging geographically or organizationally scattered knowledge. It involves knowledge about access to further knowledge (knowing who and where). If I know the sources of knowledge, I can exploit knowledge. If I do not know where these sources are, I will not know about the lost opportunities. This capability emerges from experience, learning by doing, and learning by observing. However, this capability is difficult to codify and to teach. It is becoming increasingly critical to address the knowledge economy environment in which managerial and technological knowledge is globally scattered [60: 15].

Social intelligence Human history is a path of relations. The problem of human existence itself is a relational problem, and social intelligence is a fundamental fitness mechanism. Its functions are to allow us to participate, to become part of the world, and to establish relations with other human beings. It enables human history to continue through interactions and cohabitation [1: 57]. Social intelligence involves collaboration and attention to other people's feelings [59: 17]. It consists of two ingredients: social consciousness and social influence. The former refers to a wide range of capacities, including basic empathy (the capacity to perceive human beings' emotional rather than verbal signals), empathetic attention (listening to other people, understanding other's people's thoughts and intentions), and social knowledge (knowledge of social dynamics). The latter, social influence, refers to the effectiveness of interactions

and includes influence (the power to shape the dynamics of social relations) and concern (considering other people's needs) [37, 38, 66].

Horizontal capabilities and vertical competences are complementary, not antagonistic.

Vertical competences broaden the effectiveness of horizontal capabilities in correctly exploiting the alternatives the latter generate. As mentioned, technical knowledge, a typical vertical element rooted in knowing what and knowing how, requires repetition and routine, and its improvement depends on how repetition is framed. As long as we develop a technique, the content of what we repeat changes; there are moments in which something happens that unlocks a situation, and a qualitative leap is accomplished. This is the moment of virtuous interaction between vertical competences and horizontal capabilities. Technical knowledge develops due to wishful thinking, open-minded gifts, and lateral thinking as well as through the capacity to learn by interacting and by observing. Horizontal knowledge ties are effective in generating and finding alternatives, whereas vertical knowledge is effective in developing and refining single alternatives. Horizontal knowledge improves the effectiveness of vertical deepening in offering a wider range of alternatives. Vertical knowledge reinforces the effectiveness of horizontal knowledge by analytically exploiting the alternatives generated by horizontal capabilities. Horizontal capabilities open problems, match heterogeneous fields, seek solutions far from a problem's source, and promote a network of cooperation. Vertical competences focus on local investigation, or delving into a discipline through vertical learning rooted in routines and repetition.

In next section we adopt an organizational perspective to discuss the support of distributed technologies to manage T-shaped innovators.

5 Organizational mechanisms and info-communication technology infrastructure to manage T-shaped Innovators

The emerging need for an individual T-shaped knowledge set leads to considerations about the critical issues related to their effective management. To troubleshoot high cognitive and computational complexity such as R&D and, more generally, innovative processes, organizations must be designed according to a distributed logic of knowledge exploration and integration. Horizontal capabilities are the key to addressing the needs of knowledge sharing, brokering, exploring, and recombining typical of the knowledge economy. People can no longer be seen as elements of unpredictability to be normalized; instead, they should be viewed (taking as a metaphor the dissipative structures of Ilya Progogine's Nobel Prize for Physics) as true neghentropic or, better, syntropic resources [32] that are able to generate connections between ideas, organizations, countries, cultures, and scientific fields and to widen the range of strategic alternatives [29: 194]. This vision of people as syntropic resources encourages the adoption of a distributed logic in the design of operative structures. Distributed logic means that the burden and responsibility of the organization do not focus on the head of a position or an organizational unit but are *distributed* in the sense that the framework of relations is neither strictly top-down nor dropped default ex ante. Rather, it is fluid and emerges bottom-up based on the dynamic processes of participation, and it co-evolves according to the contributions and needs of the individual in relation to the situation to be addressed (strategic innovation, product, process, promotion of a collaborative partnership).

A distributed logic requires that command and control are replaced by the coordination mechanism of self-organizing. In opposition to the rigid workflows are highly plastic

architectures whose adaptive modeling depends on the interaction of people; the structure takes on a configuration during organizing. There is no longer a sharp linear sequence between the design phase of the interaction, and the interaction itself; it is much similar to a coordination by mutual adjustment rather than via direct supervision. It is an operative structure that moves away from the classical hierarchical model and closer to the organizational structure of an open source community. The organizational design is outlined while interacting; it is a not completely a priori devised plan except in rudimentary, embryonic sketches. It is an architecture that reveals itself while individual fit each other. This view implies a relevant change in perspective from a static, structural view of organizations to a dynamic, systemic view in which the focus shifts to interaction [10]. We must replace the metaphor of pyramid building with that of a multi-polar fluid network. A mainly emergent structure, that is self-organized and designed on a distributed logic, allows us, on one hand, to tap into cognitive slack (i.e., directories or repositories of knowledge, experience, and creativity that are otherwise difficult to access on the basis of a top-down design) and, on the other hand, to amplify on a much larger scale the potential of individual capabilities. Self-organizing mechanism and distributed logic need a coherent info-communicational technological support to be implemented. The key technologies to coherently support an emergent organizational structure are *distributed technologies*. Distributed technologies, from free phone calls via the Internet to social computing through open source software, constitute an archipelago of applications, both computational and multimedia, that are independent, highly interoperable, and distributed in a network among a large number of users who are not in a hierarchical relationship. Overcoming the stand-alone applications of Web 1.0, the distributed technologies and their interaction encourage the emergence of a collaborative and organizationally more complex virtual environment: the Web 2.0. These 'weapons of mass collaboration' [64: 30], with no central allocation of resources and different properties, form a real cooperative space that enables, thousands of geographically dispersed people to co-create, a wide range of intangible and non-rivalrous output. These technologies allow for the use of cognitive slack (i.e., directories as otherwise inaccessible repositories of knowledge, experience, and creativity that are organizationally and geographically dispersed or sectorally or culturally unfamiliar) and the replication on a much larger scale of the positive features of a team-based organization (i.e., constructive confrontation, the high potential for problem solving, the development of meta-knowledge). The use of these technologies therefore supports distributed models at the organizational level (that limit, on a global scale, problem solving and the production of content for a broad spectrum of issues): from product, process, and organizational innovation to customer care and from brand management to market analysis.

One of the features of services and applications of Web 2.0 is that they allow using the network as a personal desktop. With the tools of Web 2.0 content is created, revised and distributed directly to the Web, without requiring the intermediation of traditional software stored on the hard drives of personal computers. Indeed, a typical feature of the contents developed through Web 2.0 applications is that they are governed by the neo-mechanisms of excludability (e.g., creative commons licenses) that promote their circulation and reuse.

All these features make Internet the more efficient and flexible platforms. In the Web 2.0 the "user" and "author" categories become increasingly evanescent and lose their meaning. Web 2.0 involves a relationship between administrator and user less hierarchical and more equal. Users generate their own content and dress at the same time the role of producer and consumer, thus playing the dual role indicated by the acronym prosumer: a model based on the intensive sharing of information and on an almost simultaneous generation, editing and indexing of content placed online by 'multi-role' individuals. Features easily traceable in applications such as social networking sites, wiki and folksonomies. In these and other

applications, the distributed technologies have enriched the variety and increased the power of co-ordination mechanisms that can be used in the virtual world open up to support organizational architectures, to ensure coordination of ubiquitous networks and to make viable even behind a computer monitor coordination through mutual adaptation. The technologies in question make it manageable 'choral' projects for which the burden and responsibility of the organization are not concentrated in the hands of a position or an organizational unit, but are also distributed in the sense that the structure of relations is neither strictly top-down nor dropped default ex ante, rather it is fluid, bottom-up emergent, based on the dynamic processes of participation and self-organization and co-evolves according to the contributions and needs of individual nodes.

The foregoing has important implications for what concerns the economic side of the management of T-shaped innovator with the support of distributed technologies. These technologies enable enterprises, on the one hand, to draw on repertoires of knowledge, experience and creativity otherwise inaccessible, either because they are geographically dispersed, or culturally unfamiliar. On the other hand, distributed technologies allow to replicate at a much larger scale the positive connotations of team based organization, namely the constructive confrontation, the high potential for problem solving, the development of meta-knowledge.

Application of distributed technology presents benefits of course, but also risks and costs that managers should consider. From an economic point of view, net of the costs necessary for their implementation and for their learning, distributed technologies ensure specific economies (economies of 'integration of knowledge') since the more firms use them the more distributed technologies allow them to catch value from knowledge integrating. However, the potential organizational diseconomies should not be underestimated: at the firm level, the intensive exploitation of distributed technologies can give rise to serious problems of control since they emphasize the horizontal dimension of organizational infrastructure, thereby eroding the effectiveness of direct supervision.

The principle of hierarchical authority has been a mainstay, a recurring feature in the history of social organization, from the great empires, both Western and Eastern, to the autarkic feuds of the Middle Ages; from the modern state to the capitalist corporation. What will the new balance between verticality and horizontality? In which way and to what extent the command and control will be permeated by self-organizing mechanism, and what new organizational forms will emerge from the union? The hierarchy will not be eliminated, and the principle of top-down will not disappear. However, the T-shaped knowledge-based organizations will be structures in which the vertical bar will be subjected to major stresses due to the strong push toward multipolarity, self-organization, and the search for local adaptation that is satisfactory, if not excellent. In the most extreme versions, it will be organizational forms that tend to be cash equivalents: agents will have relevant degrees of freedom in the choice of their connections and a self-allocation of effort toward the creation of a common value. The top-down logic, the hierarchy principle, and the hyper-determination obsession will be integrated and diluted with other principles, which will have to find a compromise. These may collide, but, over time, they will have to learn to share the realm of human organization. They will be 'T-shaped organizations' that do not imply an 'or' logic between vertical individual competences and horizontal individual capabilities; rather, they imply an 'and' logic between the two clusters of individual capabilities—that is, an integrating logic rather than a mutually exclusionary logic. The more the organizational model strives to promote positive feedback between the two bars of the T, the better the organization can effectively address the challenges of knowledge seeking, exploring, sharing, and re-combining on a global scale. Organizations of the past have been marked by a focus on the vertical bar competences and a shattering of the vertical segment.

The future will be based on the integration of the two bars rather than on their mutual exclusion. This orientation will involve an effort to recognize the importance of the horizontal bar for innovation of skills at the individual level and an effort to imagine and design organizations that are themselves T-shaped and to promote their development.

A synthesis of our organizational, technological, and cultural view is represented in the framework of Figure 6. We believe that the time is ripe for this sharing to occur and that the technological conditions support and stimulate the imagination of T-shaped organizational models. To implement such a view, further effort is required, both theoretically, to develop consistent management models, and empirically, to verify our hypothesis, identify managerial implications, and envisage new possible innovation scenarios.

6 Managerial and policy implications and future research

Our interpretation has several managerial implications which, in turn, open multiple future research paths.

One relevant implication at organizational level is that the presence of T-shaped innovators may equip the organization with the cognitive richness and abundance (variety) necessary to effectively survive in environmental conditions of complexity.

The principle of requisite variety, originally formulated by Ashby [3], affirms that the internal variety of self-regulating systems should match the external variety if the system is expected to adequately respond to external challenges.

The principle of requisite variety is not an abstract concept. Rather it is a very concrete managerial principle which fundamental in the *VSA* [6]: if an organization is not capable to change by adapting itself in response to external changes, it will not be able to survive. This is the essential meaning of viability [41].

The principle of redundancy is a kind of additional capability of the system which can create opportunities for growth and innovation. Without redundancy systems may remain crystallized and static. In the human brain this type of redundancy is detectable in all those connection networks that link neurons, or nerve cells, creating thousands of interconnections. The horizontal bar of the "T" is a true cognitive slack resource that generates a virtuous redundancy in organizational system, as it multiplies the cognitive frames (general schemes)

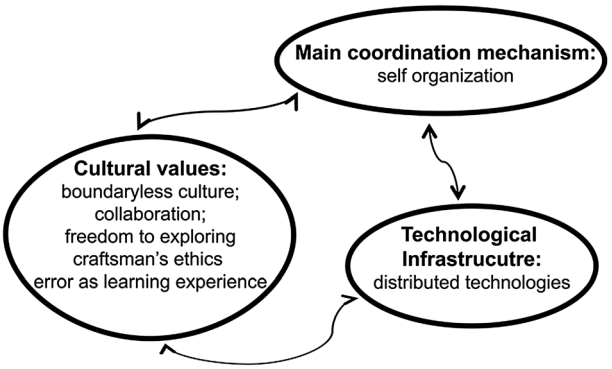

Figure 6 A scheme of synthesis of the organizational, technological and cultural aspects of the management of T-shaped innovators. Source: Our elaboration, www.asvsa.org. Figure used with permission of ASVSA

and the research hypotheses for the problem setting, which is a typical process related to innovation.

When differentiation and redundancy are extensively inserted at the local level of the organization (e.g. team work), the system is equipped with effective development capability. Individuals and team work are endowed with a capability to 'create' problems (problem creation and problem setting) and to seek innovative solutions to problems that arise locally. In essence, by promoting T-shaped managerial profiles, the teams in which they work become redundant and increase their variety: these characteristics (redundancy and differentiation) of the working groups are crucial in the knowledge economy in which only relying on single loop can be a trap, a pathology that in its efficiency puts organization on a dead end [58]. Instead, creativity, lateral and wishful thinking are essential engines of the double loop learning [58], that is, of the reconfiguration of the renewal of the general schemes that allows the organization to rethink and reinvent itself.

The key practical issue, however, remains how to develop the horizontal bar of the T. While, in fact, we are familiar with learning pathways targeted to in depth development of knowledge, which significantly leverages on technology, we are far less familiar with unconventional learning pathways both at individual and organizational level.

Clearly, we are still under the effect of the dominant specialization paradigm. Often superficially confusing the scope of 'decision making' with that of 'problem solving', 'experts' in 'complex' problems, to innovate at all costs, have forced solutions by struggling to apply known techniques to unfamiliar problems. Modern advanced society chases the 'miracles' of finance by leveraging the 'magic' potential of technique and technology. It is a society that does not notice the 'by-products' of strategies that are pursued irresponsibly and to the detriment of the environment and society. Now, the framers of the economic miracle must address an imploded economy, a destabilized society, and a suffering environment, where 'creative' finance becomes an emblematic example of a state of drunkenness that has pervaded modern man's diversion from real economy.

The advanced society has pursued innovation and progress by accumulating huge investments in technology, sometimes forgetting that they have to demonstrate their effective utility in widely solving the problems of populations and environment. Often, in fact, "companies can accumulate a large stock of valuable technology assets and still not have many useful capabilities" [65: 515].

Here is a call for service systems researchers: to direct the development of business models which could really 'serve' current but also future needs of society, economy and environment.

A shift to a more flexible, open and responsible view of organizations, less focused on the 'certainty' of the structure and technology, and open to the unpredictable outcomes of the human side of the system's dynamics which is essentially emergent in nature. A view which is capable of welcoming complexity as a source of opportunities instead of threats. Through the exploration of the unknown and the pursuing of innovation in a creative manner, the potential of resources, especially of people but also of technology and information, can be more successfully exploited in a sustainable manner.

In the current scenario of growing complexity, which challenges the systems' responsiveness to change, we essentially posit that "A Back-to-Basics Call" is needed [55: 1] by returning to key *human capabilities*. This return does not absolutely mean to neglect the fundamental role of technique and technology. It means, instead, that the key to success is not much in people or technology in themselves but in the capability to harmonically combine them within a coherent whole, i.e. in the *dynamic* capabilities.

People, and the humans' values and 'soft' skills they bring into organizations, are the keys for an effective transition toward the new *T-shaped paradigm*.

This change starts with the rethinking of university education programs which should evolve to integrate learning pathways which educate to knowledge exchange by crossing the boundaries artificially drawn between disciplines, reconciling the depth of specialized knowledge with the breadth of pure thinking. Such a change, however, should involve earlier stages of the people's learning process, being anticipated to the key phases of the education process when the young person's development involves the definition of the values systems (*categorical values*) and the key capabilities (*general schemes*) start to be formed. This wider view suggests to better integrating lifelong learning programs by widely sharing views, aims, approaches and expected outcomes.

Bridging pathways between management and engineering, and between disciplines that educate to 'think' and disciplines that push 'action', should be especially explored, as intrinsically suggested by the SSME's acronym.

By exploring the challenges of higher education, several skill profiles have been defined by Macaulay, Moxham, Jones and Miles on the basis of combination of vertical and horizontal elements, [46]: *specialist*, *generalist*, *T-shaped*, *π-shaped*, and *wedgies*. While it is clear that Service Economy demand for future skill focuses on knowledge intensive activities [46: 723], it remains unclear what kind of knowledge is required to be developed. It is interesting to note the key tole of concepts like awareness, knowledge and understanding in the definition of the educational constructs [46: 733]. Certainly, however, the required knowledge is not simply a combination of specialized knowledge in multiple domains that may result in a multiple "I" shaped knowledge that does not address the discussed requirements as it remains essentially anchored to the old paradigm. Neither the new requirements should be intended as a shift of focus from specialized to 'generalist' knowledge, which actually does not accomplish any relevant change and, from our perspective, just puts focus on the top part of the "I".

Thus, the key managerial and research issue remains the development of the horizontal capabilities, which, in our view is that of 'general level' knowledge, i.e. higher order cognition which builds upon very general, if not universal, schemes, valid across disciplines and contexts, and including values, strong beliefs, feelings, emotions, sentiment.

Educating T-shaped minded people may need a new general scheme for the education science itself. Rooting on Edgar Morin seminal work [51], a deep renewal of the current educational system needs overcoming the disjunctive paradigm, the legacy of Cartesian thought, and it needs to be rooted in the will to overcome the barriers between disciplines according to an open, multilogical and multi-perspective approach to human knowledge. A science of education that recognizes the complexity of reality should propose any problem within a multifocal model able to grasp its multidimensional nature. A teaching commitment not only to describing the structure of the phenomena (from bacteria to multinational; from automata to political parties), but also to develop learners' capabilities, such as finding solutions to a problem, also in different disciplinary fields far from those in which the problem has been formulated. An educational approach in which teachers and learners never fall in the trap 'dominant' schemes, but move along endless paths of investigation, asymptotic and therefore capable of surprise.

Probably, however, there is a need of 'T-shaped minded' people to innovatively rethink higher education programs.

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