

AS HARD AS IRON, AS SOFT AS KNOWLEDGE: HOW ARTEFACTS CAN HAMPER THE PROCESS OF ORGANIZATIONAL LEARNING

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Abstract

In this paper, we explore how physical artefacts hamper the cognitive, structural, and political aspects of organizational learning. Identifying a wide range of ways in which physical artefacts can be linked to these three aspects of organizational learning, we distinguish between four dimensions of physical artefacts (materiality, form, function, and arrangement) in order to better analyze the hampering role of artefacts. We then empirically ground our analysis into a longitudinal case study to show various impeding roles of physical artefacts. We comment on several theoretical insights and practical implications of this study.

Keywords: Knowledge, Organizational Learning, Artefact, Iran, Automotive Industry

1. INTRODUCTION

The life of organizations is not as soft as what is dominantly presented in the management literature. The early discourses in management studies, such as scientific theories, had focused on tangible aspects of organizations such as machines, factory layouts, motions and positions. However, over last half century, the fascination of management scholars about the social dimensions of organizing has pushed the physical and material aspects of organizations to the background. As a result, we are now facing a dichotomy expressed as social-material in theorizing about organizations (Engeström and Blackler 2005).

Due to the emergence of new technologies, with their material accompaniments, organizations have been exploded with a variety of complex and interconnected artefacts such as information systems, complex controlling machines, and smart and adaptable robots. On the other hand, the social dimensions of organizations have become more complex and dynamics in today's globalised and knowledge-intensive economy (Drucker 1999). Adding these two realms of complexity, the examination of the material aspects of organizations and its links with social dimensions is a rather challenging but crucial research agenda. Recently, various scholars have emphasized on the importance of examining the role of material aspects especially in studying the process of organizational learning (OL) (Orlikowski 2006; Orlikowski 2007; Nicolini 2010; Orlikowski 2010). These studies focused on “why material aspects of organizations are important for organizational learning?”, “how they could be studied in the light of extant learning theories?”, and “how can material objects and arrangements help and facilitate the process of learning”?

Building on these insights, this paper sets out to look from another angle asking “how can material aspects of organizations *hamper* the process of organizational learning?” In fact, the very presence of material objects and physical arrangements can play both facilitating and impeding impacts. We try to show that the focus on the impeding side reveals insights about the role of physical artefacts in the process of organizational learning.

Doing so, we examine two questions: (i) “how do artefacts *link* to the status quo of the organizational life?” and (ii) “how do these links play hindering roles when organizations start a learning process”?

We focus on the links between physical artefacts on one hand, and the cognitive, structural, and political aspects of organizations, on the other. Although the literature asserted that there are various links between social and material aspects of organizing, an accurate account of cognitive, structural, and political links needs further clarification. By exploring these links and how they might hamper the process of learning, we contribute to the theories of OL that examine the barriers of learning process, especially with focus on how such barriers can be linked to the physical artefacts. Moreover, by focusing on artefacts as the unit of analysis and its links with cognitive, structural, and political aspects, we show how these three realms of literature can be theoretically linked to each other. Exploring the links between various theories of learning has been pursued by focusing on other units of analysis such as “dialogues” (Mazutis and Slawinski 2008) and “practices” (Bourdieu 1977; Lave 1988). However, the potential of artefact in linking various theories of learning has been less developed in the literature.

The paper is structured as follows. In order to examine the hampering impacts of artefacts in the process of OL, we go through two steps. First, we review the literature on the socio

aspects of OL (cognitive, structural, and political) and how these three aspects can hamper the process of learning. Second, we examine how artefact can be linked to these three socio aspects. Combining these two lines of studies, we show how artefacts hamper the process of learning, *through* their various links with socio aspects. Based on a 3 year longitudinal case study, we illustrate these findings and try to empirically ground our theoretical insights. Accordingly, we conclude major theoretical and practical contributions of the study.

2. THEORETICAL BACKGROUND

2.1. Organizational learning and its aspects

Organizational learning is a rather intentional change in organizational cognition and behaviour, which involves interactions between virtually all aspects of organizations. Being a social process, OL has at least three socio aspects: cognitive, structural, and political. Each aspect can facilitate and hamper the process of learning, and be changed as the result of the learning process.

Cognitive; The cognitive aspect of organizational learning deals with the role of individual and collection knowledge (Nonaka 1994). This aspect includes various mechanisms such as creation, transferring, transformation, translation, sharing, storage, enactment, and application of knowledge. Cognitive biases (Barnes 1984), narrow scope of search and exploration (Hedberg 1981; March 1991), and the domination of existing logics (Bettis and Prahalad 1995) are some important examples of cognitive barriers which have been discussed extensively in the literature. These barriers are either focused at the individual level, such as biases in the process of information, or are trying to show some kind of shared cognitive barriers at the aggregate level. In order to explain how cognitive barriers can emerge and sustain at the aggregate level, theorists have adopted several concepts such as routines (March 1991), practices (Nicolini and Mezner 1995), or dialogues (Mazutis and Slawinski 2008). However, the role of artefacts as a medium that not only can maintain the hampering impacts of established cognition, but also can explain the connections between the individual and collective levels is less developed, if glossed over (Kim 1993).

Structural; OL involves various structural dimensions such as the structure of tasks and responsibilities, processes and routines. The very nature of organizational structures implies stability and persistency of patterns of behaviour. In fact, one of the crucial functions of creating establishing organizational structures is to maintain the expected sort of behaviours. Hence, once these structures act against the new learning process, they appear as barriers. Rigidities created due to organizational structure, routines, formal contracts, and patterns of relations within and between organizations are just a few examples of structural barriers (Stern and Sundelius 1997; Fang, Lee et al. 2010). A key question is how do the hampering impacts of organizational structures *sustain* over time? In an ironic term, what makes organizations to keep their yesterday's structures once they start a new working day in the morning? The stability of organizational structures has been explained through their cognitive roots, when they are stored and learned in the individual memories, habits and learn patterns of practices (Nelson and Winter 1982), formalized institutions such as rules and regulations. Material artefacts, either in the form of physical settings, machines, technologies, or positions and spatial arrangements, also contribute to the stability of

organizational structures. In fact, *materialization* of organizational structures helps them to sustain over time and over places.

Political; Politics, defined as the state and “dynamics of power” (Blackler 2000; Coopey and Burgoyne 2000) is a crucial aspect in the organizational learning. The established settings of power and interests among influential actors shape the learning process. In addition, the process of learning often involves serious political dynamics caused by those who might feel insecure (“losers”) to maintain their power against those who aptly pursue the learning aims (“winners”). Therefore, political barriers are common when learning agents are actively involved in this process. Conflicts between different groups of agents (March 1962; Coopey 1995; Vince and Saleem 2004), creating coalitions against the learning (Cyert and March 1963; Argyris 1999), the actions of influential actors and elites to deviate or stop learning process (Krackhardt 1990; Sievers 2001), creating blaming games and instigating debates that devalue or at least delay learning activities (Scruton 1999; Moynihan 2009), inactions and bold interventions (Stern 2002; Ferdinand 2004) are important political barriers to the learning process. How these political barriers can be linked to the artefacts is directly related to how political powers and political dynamics are linked to organizational artefacts. We will comment on these links once we described the artefact in the next section.

2.2. Artefact: definition, characteristics, and typology

It is difficult to find a straightforward definition of artefact in the literature of management. Some scholars adopt a wide conception that virtually includes anything except human agents and their actions. For instance, Macpherson and his colleagues (2010) refer to artefact as something “including tools, procedures, regulations, processes, concepts and accepted practices” ((Macpherson, Kofinas et al. 2010), p. 305). However, some other scholars have adopted a more exclusive definition that only refers to material objects. Asking the reverse questions might be more insightful for the sake of construct clarity: “what is *not* artefact?” There is a rather consensus in the literature that “human agency” (Winner 1986), “individual and social practices” (Orlikowski 2006; Nicolini 2010), and “dialogue and discourse” (Nicolini 2010) are other social constructs that are clearly distinguished from artefacts. The heterogeneity of terminology used for artefact reflects differences and also lack of agreements at the conceptual level. Many authors have used general terms such as “artefact” (Macpherson and Jones 2008; Macpherson, Kofinas et al. 2010) “object” (Pels, Hetherington et al. 2002; Macpherson and Jones 2008; Macpherson, Kofinas et al. 2010) and “thing” (Miettinen, Lehenkari et al. 2008). On the contrary, some authors tried to use more specific terms such as “materiality” (Orlikowski 2006) in order to emphasize on the material aspects of the artefact or “technology” or “technological artefacts” (Orlikowski 2006) to refer to specific categories of artefacts such as new and complex artefacts.

We found ten characteristics of artefacts that authors have used in order to define this concept and distinguish it from other concepts.

Tangibility; Artefacts, compared with other organizational phenomena, are more tangible and articulated. We can easily refer to them and identify them. Part of this tangibility is rooted in the fact that the we deal with artefacts in the “day-to-day work” (Macpherson, Kofinas et al. 2010).

Objectivity (partially); Compared with other social entities, artefacts are rather objective and impersonal (Berger and Luckmann 1966; Winner 1986). Here objectivity means that artefacts can be approached and identified by various actors in a *rather* consistent and similar way. However, this *partial* objectivity does not dismiss the fact that social actors can still interpret and reconstruct artefacts subjectively (Berger and Luckmann 1966). Being impersonal, artefacts are less directly linked to human agents. For instance, unlike human actions, artefacts cannot be attributed to a single person or group. Accordingly, we cannot foist some personal attributes (such as having intention) to a person, nor can we apply some social actions (such as blaming or accusing) to them (Winner 1986).

Having symbolic and epistemic content; Artefacts, even in the form of physical objects, have symbolic aspects and possess epistemic content in the organizational life (Engeström and Blackler 2005). Having symbolic aspects, objects might convey ideas and represent values that are not necessarily bound up with their physicality. For instance, the logo of a company, regardless of its design and colours, can be linked with some ideas and values. Similarly, artefacts have epistemic content which help them to maintain some knowledge as they are moved across time and space (Pels, Hetherington et al. 2002; Miettinen, Lehenkari et al. 2008).

Interconnectedness and being socially shared; Artefacts are social phenomena as they play crucial roles in the interactions among human agents. In fact, they are intensively embedded in the web of actions and interactions between individuals and groups (Orlikowski 2006) and among a social community (Engeström 2001). Therefore, artefacts play as glues and links in the social interactions (Berger and Luckmann 1966; Schatzki 2005; Macpherson, Kofinas et al. 2010). They are “active mediators” in social interactions (Pels, Hetherington et al. 2002). They can be linked with other artefacts (Pels, Hetherington et al. 2002) when they are physically or symbolically linked with them, and they can be connected with human agents by mediating them with their actions (Vygotsky 1978; Engeström 2001; Schatzki 2005; Orlikowski 2006; Nicolini 2010).

Socially constructed (partially); Being socially shared, artefacts are *partially* constructed by social actors. In fact “objects are constructed by actors as they make sense, name, stabilize, represent and enact foci for their actions and activities.” ((Engeström and Blackler 2005), p. 310). As a result, the subjectivity of social actors can be partially imposed to them, leading to the fact that artefacts can be differently used, interpreted, identified, and valued by different agents (Harré 2002). In another word, artefacts are partially disputed by social actors.

Active and coercive impact; Although artefacts are partially constructed, this partiality is limited to the level that the nature of artefacts allows. In fact, each artefact has its own inherent tendency to force some sort of social orders to the social actions. Some authors used the terms “active” and “coercive” (Pels, Hetherington et al. 2002) to convey this aspect of artefacts (Engeström and Blackler 2005). Unlike some social entities, artefacts are not fully flexible to any kind of construction and reconstruction. They have their own “built-in affordance ” ((Engeström and Blackler 2005), p. 310) to accept such symbolic or epistemic roles. Especially physical artefacts are somehow hard enough not to be interpretable and constructed in any way (Pels, Hetherington et al. 2002). In another words, they have some sort of “will as force” (Brown and Capdevila 1999).

Stability (partially); Artefacts are partially stable which helps them to maintain their role along time and space (Pels, Hetherington et al. 2002). As a result, artefacts can stabilize and sustain patterns of practices and knowing in the organizations (Nicolini 2010). This stability is more obvious in the physical artefacts as they can use the materiality to serve their stability (Orlikowski 2006).

Transient (partially); Nevertheless, artefacts are partially transient. Artefacts are created, modified, and abandoned by social actors (Thompson 1979; Engeström and Blackler 2005). They are subjects of various changes due to economic and social reasons. For instance, product's design continuously changes due to the new customers' needs. In addition, the connection between artefacts (arrangements of artefacts) can also be changed, even the artefacts themselves remain constant (Schatzki 2005).

Value-laden; Artefacts are value-laden in economic and social terms. Economically, artefacts, such as machines, products, and facilities, have their own economic value (Engeström and Blackler 2005). Socially, some artefacts are more valuable than others as they can serve some specific social aims.

Silent; Finally, artefacts are rather silent social elements, compared with human agents (Nicolini 2010). For this reason, they might be overlooked in our theories and practices.

To sum up, artefacts are socially shared objects that are partially constructed by social actors, and at the same time have coercive impacts on them. Although they possess a rather stability, they are transient as they evolve over time. They are silent, though they play salient roles in the organizational life. A summary of these characteristics is presented in Table 1.

Table 1: Characteristics of artefacts

Characteristics	Description	References
Tangibility	Artefacts are easily understandable, and we play with them our day –to-day work	(Macpherson, Kofinas et al. 2010)
Objectivity and being impersonal (partially)	Artefacts can be identified and perceived by various subjects in rather similar way; artefacts are not directly attributed to persons or groups and cannot possess human agents	(Berger and Luckmann 1966) (Winner 1986)
Having symbolic and Epistemic	Artefacts are attached to social ideas and values and embed knowledge	(Engeström and Blackler 2005) (Miettinen, Lehenkari et al. 2008) (Pels, Hetherington et al. 2002)
Interconnectedness and being Social and shared	Artefacts are linked with social actors and interactions and are shared among social communities. Artefacts are linked with other artefacts and can mediate between human agents and social actions and practices	(Berger and Luckmann 1966; Engeström 2001; Orlikowski 2006; Macpherson, Kofinas et al. 2010)
Constructed (partially)	Artefacts are identified, named, interpreted, valued, and used by social actors	(Engeström and Blackler 2005) (Harré 2002)
Active and coercive (partially)	Artefacts have their inherent tendencies to shape and affect social actions and are partially inflexible to be constructed in any way	(Engeström and Blackler 2005) (Pels, Hetherington et al. 2002) (Brown and Capdevila 1999) (Orlikowski 2006)
Stability (Partially)	Artefacts have a rather stability over time and space	(Pels, Hetherington et al. 2002) (Nicolini 2010)
Transient (Partially)	Artefacts are created, modified, and abandoned over time	(Thompson 1979; Engeström and Blackler 2005)
Value-laden	Artefacts have economic and social values	(Engeström & Blackler, 2005)
Silent	Artefacts play their roles in a rather silent way	(Nicolini 2010)

According to artefact types, literature distinguishes between two types of artefacts: physical and non-physical (Pels, Hetherington et al. 2002). Physical artefacts such as products, technologies (hardware), and machines have some kind of materiality (Orlikowski 2006; Miettinen, Lehenkari et al. 2008), while non-physical artefacts have no such material aspects. Physical artefacts are then classified into “material objects” and “material settings”. The former refers to a single object, while the latter refers to the “set-ups of material objects” (Schatzki 2005), p. 472). Non-physical artefacts are categorized as “symbolic” (Macpherson, Kofinas et al. 2010), “cultural” (Miettinen, Lehenkari et al. 2008), “linguistic” (Engeström and Blackler 2005), “epistemic” (Engeström and Blackler 2005) artefacts. Admittedly, there is no clear or consistent use of these sub-categories in the literature. For instance, some authors have used “symbolic” artefacts equal to “non-physical”, while others have a more specific categorization of non-physical artefacts in which symbolic artefacts are only one subcategory.

What is rather clear is the distinction between non-physical and physical ones (Macpherson, Kofinas et al. 2010). This distinction is linked to the debate between symbolism and materialism (Pels, Hetherington et al. 2002) which has a direct bearing on the characteristics of artefacts. More specifically, materiality provides artefacts with more tangibility, objectivity, and stability (Latour 1991), and tends to tilt the balance towards coerciveness of artefacts. In contrast, non-physical artefacts are more subjective, malleable, interpretable, and fuzzy (Miettinen and Virkkunen 2005) than physical ones. We believe that accurate theories about artefact and its role in organizational dynamics should consider these differences. However, except some works that focused only on the material artefacts (Winner 1986; Orlikowski 2006), the literature has remained general at the communalities of all types of artefacts. Additionally, remaining at this general level, we might fall into the trap of including almost all social entities as artefacts which in turn vanishes the clarity and usefulness of this construct (Suddaby 2010). Thus, we merely focus on the physical (= material) artefacts in order to provide a more accurate and specific account of this construct. Moreover, this strategy helps us to better examine how the materiality of artefacts can play hampering roles against the learning process.

2.3. Artefact and organizational learning

Before we examine the links between artefacts and organizational learning, we should consider how artefact can be theoretically framed. Artefacts can be the *subject* of organizational learning when learning requires creating new artefacts, abandoning them, modification of existing ones (Blackler 1993; Macpherson, Kofinas et al. 2010) or changing the arrangements of them (Schatzki 2005). In this way, the transient and socially constructed aspects of artefacts are moved to the foreground, while their stability and coerciveness is pushed to the background.

Artefacts can also be viewed as part of the *context* of organizational learning where the learning process is taking place. For instance, the physical layout of factory can limit some interactions among learning agents in order to learn indirectly from each other (Ewenstein 2009). In this view, the focus of analysis is on the stability and coercive nature of physical artefacts and their arrangements (Schatzki 2005) that can shape (Macpherson and Jones 2008; Macpherson, Kofinas et al. 2010), sub-tend, and even determine the scope of (Schatzki 2005) learning actions. In addition, artefacts “can create space and time for reflection and learning” (Macpherson, Kofinas et al. 2010), p. 303). Some authors used

other terms as “site” (Schatzki 2005; Nicolini 2010) or material “context” referring to the contextual role of artefacts.

The third way of framing artefact is as *elements in the process* of OL. In this view, artefacts are neither so passive (as they are when they are subjects of learning) nor quite active (as they play role as contextual factors). Instead, they are in the constant co-evolution with learning practices in the very daily activities (Orlikowski 2006). Pickering (1995) refers to this point as “the reciprocal and emergent intertwining of human and material agency” ((Pickering 1995), p. 15). In fact, artefacts are inextricable accompaniments of learning actions that human agents perform. In this view, human agency can actively use artefacts to *perform* its actions (Miettinen, Lehenkari et al. 2008), *extend* and *complete* its agency power through time and space and to actions that would be otherwise impossible to do, *create links* with other human agencies, *stabilize* the social practices, and *reconfigure* the existing social relations (Orlikowski 2006). Furthermore, artefacts can represent and mediate learning actions as well as invoking practices and encourage collective learning (Macpherson, Kofinas et al. 2010). Artefacts, in the form of instruments, can also help learners to better connect themselves to the world and spare knowledge about it. For instance, information systems are nowadays crucial elements in the process of learning (Baird 2004). More specifically, focusing on some objects in the process of OL, actors can better follow the transitions in the learning process as artefacts make it more concrete (Engeström 2001).

2.4. The links between artefacts and cognitive, structural, and political aspects of OL

The above discussion reveals that artefacts are inextricably intertwined with organizational learning, either as the subject, context, or part of the process of learning. Studying *how* artefacts are linked with the organizational aspects, although expressed as one of the most insightful lines of research (Starbuck 2003), still requires further attention (Latour 2004; Orlikowski 2006). We put one step further to examine how artefacts can be linked to organizational cognition, structure, and politics. The overall approach of literature in identifying these links is to explain how artefacts can facilitate the process of learning (Macpherson and Jones 2008; Macpherson, Kofinas et al. 2010). However, we want to look at these links from another angle to examine how these links can hinder organizational learning.

2.4.1. Cognitive links

We could find six ways in which physical artefacts can be linked to organizational cognition.

Artefacts are known by individuals (knowing about); The simplest link between artefacts and organizational cognition is through individuals’ knowledge, when they *know about* artefacts (Orlikowski 2006). Knowing what the artefact is and how to use it in the social interactions, individuals are somehow linked to the underlying artefacts, cognitively. This knowledge includes both mental contents and bodily tacit skills (Polanyi 1966).

Artefacts embed and store knowledge; Artefacts themselves embed knowledge, what is often referred to as “embedded” (Blackler 1995) knowledge. However, depending on how we conceptualized knowledge, this embodiment can be interpreted differently. In a positivist and individualistic notion of knowledge where knowledge represents the reality

(Rorty 1979), the embedded knowledge means that some areas of knowledge (for instance in the form of physical laws) are used in making the artefact which can be re-gained through a process of analysis of the artefact (for instance doing some reverse-engineering). In addition, artefacts might *remind* learners about some knowledge which has been learned before. In another words, the artefact *uncovers* cognitions and beliefs (Engeström and Blackler 2005). Accordingly, the knowledge is *stored* in artefacts in that, once the artefact is moved across time and places, the same content of knowledge can be restored. In a rather interpretative view of knowledge (Schutz 2005), artefacts also represent subjective understandings and values (Miettinen and Virkkunen 2005) that are somehow linked to them. They are, in this view, “envelopes of meanings” (Engeström and Blackler 2005) which encompasses strong subjective elements. Finally, in a performative and action-based view of knowledge (Orlikowski 2002; Nicolini 2010), there is no knowledge stored in the artefacts, but artefacts continuously constitute specific patterns of practices (knowing). In any case, this link between artefacts and knowledge makes a basis that knowledge can be accumulated and sustained over time and across space.

Artefacts share and transform Knowledge; Artefacts are linked with organizational cognition when cognition becomes fluid to transfer and transform. Carlile (2002, 1997b) shows how some artefacts act as boundary objects to cross the cognitive boundaries and interaction and integration between various cognitions (Carlile 1997; Carlile 1997; Carlile 2002). Once the knowledge interactions are focused on a specific artefact, the understanding of social actors might be transformed (Callon 2002; Macpherson, Kofinas et al. 2010). Artefacts might be used also as a source for creating debates and conflicting ideas and cognitions (Thompson 2004). However, artefacts might sustain some cognitive boundaries as their reconciliation requires subsequent changes in the artefact (Schatzki 2005; Macpherson, Kofinas et al. 2010).

Legitimising and formalizing vs. de-legitimising and limiting; The very presence and domination of some artefacts can legitimise and formalize areas of knowledge that are somehow linked or related to them. For example, as far as the analogue electronic systems are dominant technologies, the knowledge of analogue electronics has a privilege over the digital knowledge. Alternatively, the rival knowledge areas can be de-legitimised or overlooked due to the strong link between the artefact and the related knowledge areas. In fact, artefacts are “defining the possibilities and scope of understanding...” ((Macpherson, Kofinas et al. 2010), p. 305) of associated knowledge areas. This legitimisation sometimes stems from the technical content of knowledge as other knowledge areas might be technically incompatible with the existing artefact (like the relation between analogue devices and analogue electronics knowledge), while in some other cases this link is socially constructed and has little to do with the technical fitness.

Artefacts use and institutionalise knowledge; Another link between artefacts and knowledge comes from the fact that a specific artefact makes some knowledge areas to be used and become organizationally established. For instance, using the computers, instead of paper-based systems, the knowledge of typing will be institutionalised. Similarly, some of these links are not necessarily rooted in the design or features of the artefacts, but for some other economic or social reason, this link is established over time.

Artefacts create new knowledge; Finally, artefacts can create new knowledge and establish new cognitive links with the organizational cognition. In the field of epistemology

of thinks, scholars have discussed that using specific artefacts can produce new knowledge about the world (Baird 2004; Miettinen, Lehenkari et al. 2008). In a positivistic view, playing with the artefacts can lead us to uncover new knowledge about the world, whereas in a rather interpretative perspective, the application of artefacts can construct new meanings (Macpherson, Kofinas et al. 2010). From the view of practice-based theorists, artefact might have a secondary, temporal, and emergent role in the construction of knowing, like the role of scaffolds in the construction of a building (Orlikowski 2006).

To conclude, artefacts can establish heterogeneous links with organizational cognition at both individual and collective levels. These links can present simultaneously, and reinforce each other. A summary of the cognitive links is presented in Table 2.

Table 2: The cognitive links of physical artefacts

Cognitive link	Description	Scholars
Knowing about artefacts	Actors are linked with the artefact cognitively because they know about it	(Orlikowski 2006)
Knowledge embedded in artefacts	Some areas of knowledge are embedded in the artefact and artefact represent and maintain the knowledge	(Engeström and Blackler 2005) (Blackler 1995) (Miettinen, Lehenkari et al. 2008) (Miettinen and Virkkunen 2005) (Engeström and Blackler 2005)
Artefact share and transform knowledge	Artefacts is linked with some area of knowledge because it is used to transfer and transform ideas about these knowledge areas	(Carlile 1997; Carlile 2002) (Carlile 2002) (Carlile 1997; Carlile 1997) (Schatzki 2005; Macpherson, Kofinas et al. 2010) (Callon 2002; Macpherson, Kofinas et al. 2010) (Thompson 2004) (Macpherson, Kofinas et al. 2010)
Artefact legitimises and formalizes knowledge as well as de-legitimizing and limiting knowledge	Artefact is linked to knowledge because the dominance and legitimacy of artefact is transcended to knowledge areas attached to it. Also, artefact can de-legitimise or limit areas of knowledge which are not cognitively linked with the knowledge embedded in it	(Macpherson, Kofinas et al. 2010)
Using and institutionalising knowledge	The active application of artefact makes the related knowledge used and institutionalised	
Creating new knowledge	Artefact helps to generate new ideas, meanings, and knowledge	(Miettinen, Lehenkari et al. 2008) (Baird 2004) (Macpherson, Kofinas et al. 2010) (Orlikowski 2006)

2.4.2. Structural Links

Physical artefacts can be linked with organizational structures in various ways (Button 1993; Berg 1997; Orlikowski 2006). First, the very division of labour can be *shaped around* some artefacts such as the final product or used technologies. Accordingly, the roles and responsibilities and the lines of command and hierarchies are defined according to them (Pavitt 1998). At a lower level of daily practices, artefacts also *structure* practices (Schatzki 2005). For instance, artefact might limit the emergence of some kind of behaviours and pave the way for the others. In this way, artefacts and patterns of performing practices (routines) are coupled and sustained over time, artefacts call for such routines, and those routines maintain the presence and application of the artefact. Thirdly, artefacts can entail some specific institutional relations (Orlikowski 2006) within and between organizations. To illustrate, the architecture of a product can determine the

relations between suppliers, assemblers, and final producers. Fourthly, some artefacts legitimise some specific structures. Engerstrom and Blackler (2005) refer to this linkage between artefact and structure as “ceremonial roles” of artefacts (Engeström and Blackler 2005). Table 3 summarizes these links.

Table 3: Structural links of physical artefacts

Structural link	Description	Scholars
Shaping overall structures	Overall structure of organizations can be shaped based on some essential artefacts	(Pavitt 1998)
Co-evolution with routines	Artefacts and patterns of practices are coupled in a constant co-evolution	(Schatzki 2005) (Orlikowski 2006)
Entailing institutional relations	The characteristics of artefacts requires some specific intra and inter organizational relations between structural elements	(Orlikowski 2006)
Legitimation of structure	Artefacts and structures have mutual legitimization impacts on each other	(Engeström and Blackler 2005)

2.4.3. Political Links

The links between artefacts and organizational politics is rather less developed in the literature. We could identify three ways in which politics and artefacts are connected. First, the design or functionality of artefacts, might require or be compatible with some specific political settings (Winner 1986). More specifically, the active presence of a specific artefact might practically (not logically) facilitate the dominance of certain groups over the others. This link can be either loosely established through social mechanisms, or be inherently rooted in the very specific forms or characteristics of the artefact (Winner 1986). In the former, the change in the political setting does not necessarily imply subsequent changes in the artefact, while in the latter, such changes are inevitable.

Second, the dynamics of power in organizations can also have linkages with transitions in the artefacts. On the one hand, political dynamics can influence selecting one form of artefact over another which is more compatible with the interests of stakeholders. On the other hand, some changes in the artefact can destroy the established power setting and creating political tensions and instability in the organizations (Pels, Hetherington et al. 2002). This linkage between artefacts and organizational politics is more obvious when a wide range of possibilities for the new artefact is available and they are rather invariable in terms of the technical and structural reasons (Akrich 1992).

Third, and following the previous two links, the presence and specific form of the artefact can reveal and *reflect* political settings, as well as past political dynamics (Engeström and Blackler 2005). In fact, “political qualities and purposes became ‘fixed’ in the material design and physical dimensions of technical artefacts themselves” ((Pels, Hetherington et al. 2002), p. 7). In another words, political aspects of organizations are “script into” artefacts (Akrich 1992). In Table 4, these political relations are summarized.

Table 4: Political linkages of physical artefacts

Political link	Description	Scholars
Fitness between political structure and artefact	Artefact might require or be compatible with some specific political settings.	(Winner 1986)
Co-evolution of political dynamics and transition of artefacts	The political dynamics can be coupled with the transition of artefacts.	(Akrich 1992; Pels, Hetherington et al. 2002)
Reflection and revealing the politics	The presence and form of artefact can reveal or reflect the power structure and past power dynamics.	(Pels, Hetherington et al. 2002; Engeström and Blackler 2005)

2.5. A more precise view of artefact

The links between artefact and socio dimensions will be better understood if we distinguish between at least four dimensions of physical artefacts: materiality, form, arrangement, and function. Firstly, the very material presence of the artefact, as compared with emptiness, is the lowest and simplest dimension. In this sense, the very materiality and which materials are used in the constitution of the physical artefact is important. However, most of the social analyses of artefacts go beyond this level. Secondly, physical artefacts have a *form* or *architecture* that which refers to their shape, their constituting elements and how they are linked to each other. Thirdly, the artefact itself is often an element in a wider web of interconnected artefacts. In this sense, the *arrangement* of the artefact in relations to other artefacts is the focus of analysis. Sometimes we refer to this dimension as “set-up” of artefacts, “layout”, or “material arrangement” (Schatzki 2005). This dimension of artefact is more aggregate and holistic than previous ones. Fourthly, artefacts serve a series of *functions* in the organizations. Although the functionality of artefacts is linked with their materiality, form, and arrangements, it can be analysed as a separate dimension. For instance, sometimes in spite of changes at the other dimensions, the same functionality can be achieved.

Although there are various insights in the literature on how artefacts can be linked to organisational aspects, the literature is not specific about the distinction between these four dimensions of artefacts. In fact, our claim is that any of these dimensions can play different roles when we want to analyse the role of artefact in the process of OL. For instance, some of the political dependencies are applicable to the selection of one *form* over another or it can be related to which *function* of the artefact is favoured. We would argue that a more accurate account of artefact which distinguishes between these four dimensions can yield in more specific and insightful theories about their role in the organizational learning.

Having this framework in mind, we try to explore and empirically illustrate various links that each dimensions of physical artefacts (materiality, form, setting, and function) can establish with three socio aspects of organisational learning (cognitive, structural, and political). Figure 1 presents this theoretical framework.

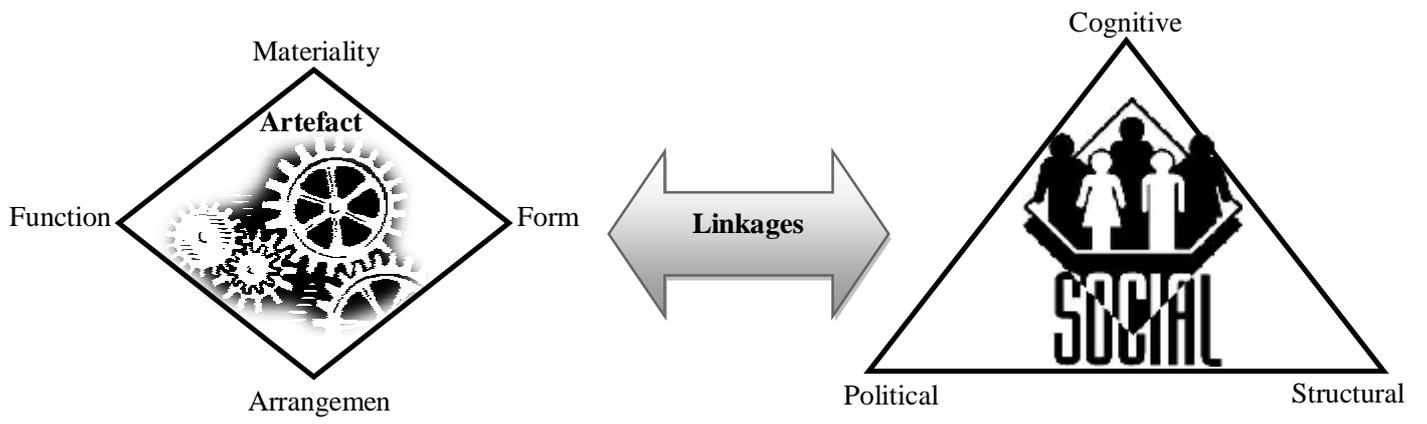


Figure 1: Graphical illustration of theoretical framework

3. AN EMPIRICAL ILLUSTRATION

3.1. Case study setting and methodology

The main research question of this study is how physical artefacts are linked to the cognitive, structural, and political aspects of organizations, and how these links hamper the process of learning. More specifically, we focus on a process of change where an artefact plays a central role in order to examine how four dimensions of artefacts are linked to three aspects of organizational learning and how these links play hampering roles in the process of learning.

Following the aims of this study, we adopted a qualitative longitudinal cases study which allows us to collect rich data about different aspects of the artefacts and how they are linked to cognitive, structural, and political aspects of organization. Moreover, the longitudinal setting helps us to examine how these links are playing over the course of learning process and how they impede this process.

Three of the researchers were actively involved in the process of change. Hence, they could collect data about all aspects of the artefact and its role in this process through daily participatory observations over three years. We also ran seven complementary interviews with other managers and experts in order to complete and cross check of our findings. In addition, we analysed all available technical and managerial documents.

We analysed data to identify the main characteristics of the artefacts and their role in the process of learning. How these artefacts were linked to any of the three social dimensions. Moreover, we explored how the learning process were opposed and hampered, in order to see how these links contributed to them.

The selected case is a significant change in the core product of largest national automotive company in Iran through which the old design of engine. The selection of this case was done based on several reasons. First, the role of artefact (engine) and its changes in this learning process was crucial. Second, the change was so large that involved a wide range of cognitive, structural, and political aspects of learning. Third, the researchers not only were active observers of the whole process of change, but also had access to informants and other sources of data.

3.2. The process of organizational learning at OKCO

National and Sectoral policy of Iran in last decade required upgrading technological capability in Auto industry which was fast growing section in Iran (the average growth rate of this sector has been more than 20% per year over last 15 years). This strategic shift means upgrading from just foreign brands assembly (mainly UK, France, and South Korea brands) to strategies of local brand and local design. IKCO as biggest company of Iran and biggest automotive company in the Middle East and Africa, developed a national brand, named SAMAND car. This vehicle was developed based on Peugeot car (Peugeot 405 car platform including XU7 engine).

Following these strategic moves from assembly to local brand and design in auto industry of Iran, IKCO planned to develop its own brand engine, named EF engines. These

engines are gas-based dual fuel (CNG¹-gasoline) and include two main sizes²: 1700cc (EF7) and 1400cc (EF4). Both EF7 and EF4 engines also have two types: natural breathing and turbo-charge engine. Among these ones, the first and the most important project was EF7 that is our case study candidate.

IKCO established a company named IPCO³ as responsible for this project. The project involved an alliance between IKCO and FEV GmbH, one of the leading German companies in engine design technology in the world. The objective of this collaboration was the development and commercialization of EF engines. This project involved many domestic and foreign companies in auto value-chain.

The starting point of the engine technologies development gets back to year 1997 that engine R&D centre established and managed related activities in IKCO (Table 5). CEO has influential effects on main projects and the change of CEO on September 2002 had influential effects on EF project including the selection of engine type and technology and also foreign partner and main project implementation. IKCO founded IPCO to manage engine-related activities and projects and planned national brand engine (EF7) project on year 2002. After one year, EF7 development started on 2003 and after different phases of product development in 4 years, EF7 first real prototype opened by Iran president on March 2007. This prototype needed more development to launch of the engine on vehicle and complement commercialization phase that took 1 year and first launch of EF7 on SAMAND car took place on year 2008. The other main event was auditing of Iran leader from EF7 manufacturing line that happened on March 2010 and had influential effect on engine development on commercialization.

Table 5: Main events of EF7 project

Date	Main event
Summer 1997	Engine R&D centre establishment in IKCO
September 2002	CEO change of IKCO
Winter 2002	IPCO establishment and strategic decision of EF7 project
Autumn 2003	Beginning of EF7 Project in IPCO
March 2007	Opening of EF7 prototype Iran president in IKCO
Winter 2008	First launch of EF7 on national brand car (SAMAND)
March 2010	Auditing of Iran leader from IKCO and EF7 production line

Shifting form old engine to new one made huge change in IKCO Corporation. Old engine was produced under license of Peugeot Company and its responsibility for product and process technologies. Old engine was produced for many years and because of accumulated knowledge and learning, production was routine process in IKCO. Many parts were localized and components supplying, engine assembly and after-sale services occurred in stable settings. In contrast, new engine that IKCO was responsible for design and manufacturing, changed different areas. Many parts get to be new (both in technology and production) localized in IKCO supply chain and some other parts imported from new sources. Therefore many new local and foreign companies entered in IKCO network. New manufacturing and assembly lines were established inside the IKCO. Company developed

¹ Compressed Natural Gas

² There are some other projects for development of single-fuel types: EFD for Diesel and EF7NE for petrol.

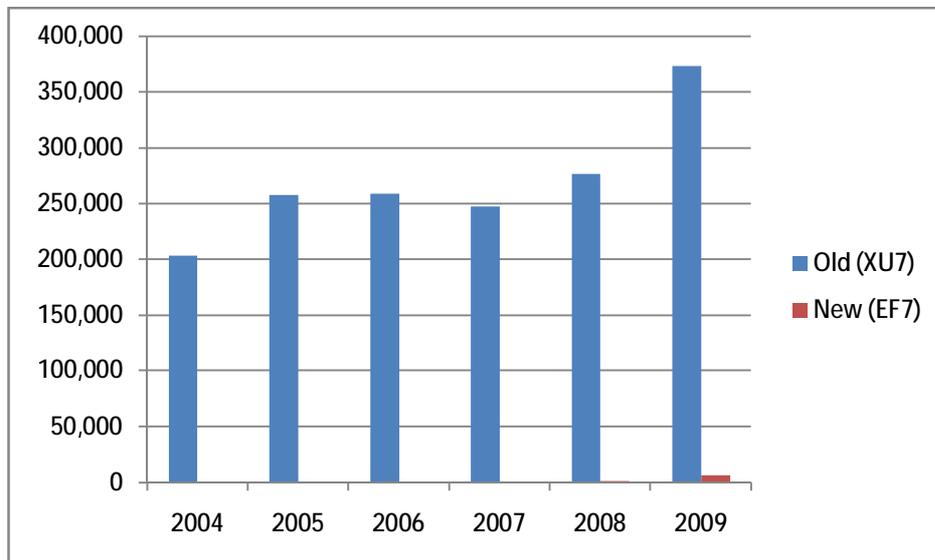
³ Irankhodro Powertrain Company

various knowledge and skills throughout different divisions (e.g. product development, production engineering, after-sale division, manufacturing line, supply chain network).

The project had wide and deep effects at macro (nation-wide), meso (auto industry) and micro (IKCO) levels in terms of economics, industrial, technological and organizational achievements. In spite of various successful outcomes, there have been some considerable deviations in project performance in these areas: EF7 ramp-out and replacing rate instead of existent XU7 engine and the cost of development and production.

The project target was that EF7 to be installed on SAMAND on 2008 in considerable ramp-up rate with competitive price. Development time took more than 7 years (2003-2010) instead of 4 years (2003-2007). It was targeted that new engine to be replaces of old one in considerable rate, but production and replacement ratio was lower than planed one (Figure 2). Development investment and EF7 prices were also higher than targeted amounts.

Figure 2: Engine production Number in IKCO 2004-2009



There were some challenges against change process that made above problems. The important challenges were technical, managerial, organization and political challenges. New engine includes many technologies that were new to the company. These technologies were used in design, production and after-sale of engine and its components and were also more complex and high-tech. Other challenge posits in project execution and administration. Identification of influential members and coordination them has vital important in development projects. Project leaders focused more on technical side, involved more design partners and undermines components suppliers and production owners in IKCO. This made considerable delay in commercialization process, because not preparation of production facilities in IKCO and supplying of components in supply chain. Other challenge gets back to organizational arrangements generated from contract changes. Changing from the old engine to new one required some contracts in supply chain to be cancelled or revised. Political challenges also were influential in mentioned problems. This project based on national capabilities and in more independent way from foreign companies. Some managers didn't believe this approach and preferred developing and

manufacturing foreign brands. Moreover some managers had considerable gains from current setting inside the IKCO and within the supply chain. Changing from old engine to new one was against their interest or preferences that made some barriers.

3.3. Artefact change as the core of learning process

According to above change story, main element of the story is artefact, new IKCO EF7 engine instead of existent Peugeot XU7 one (fig. 3).

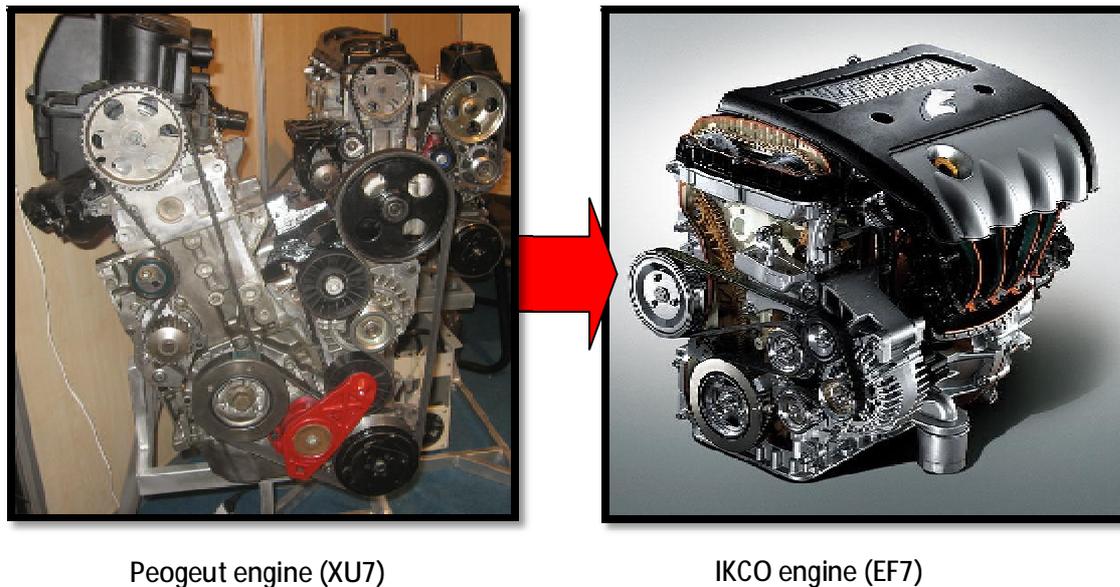


Figure 3) Artefact changes in EF7 engine development

Each engine typically consists of two main areas: main components and peripheral components. Main components include components like cylinder, cylinder head, piston, camshaft, flywheel, valves and manifolds. Peripheral components include parts such as ECU, Oxygen sensor and alternator. In terms of artefact view, two engines have following differences (hard differences)⁴:

- § **Addition** some new components. New components added to engine design specially in peripheral area like CVVT, accelerator pedal and automatic tensioner. These affected the functionality of the artefact. This change required new material is supplied and significant changes be applied to engine's architecture.
- § **Modulation** of some components in one module. For instance, water pump, oil pump and oil coolant system are all integrated in one place. These changes affect architecture of the engine.
- § **Arrangements:** Changes in related **non-engine components** for packing and integration in vehicle such as engine-mounting, clutch system, gearbox housing, gear levers and clutch levers. As a result, the relations between engine and related artefacts changed.

⁴ In this view, we ignore non-artefact differences such as technical specification, production infrastructure and so on. In fact these are consequences of artefact change.

§ **Advancement** in parts and using high-tech components that led to more **complex** and **integrated** engine. Accordingly, the functionality of engine changed.

In order to achieve the new artefact from the old one, various changes took place throughout the organization. In other words, organization requires following changes to make success change from old engine to new one. Some cases of artefact change and their consequent organizational changes displayed in Table 6:

Table 6: Organizational changes and associated changes in artefact

Organizational change	Dimensions of Artefact change			
	Materiality	Form	Function	Arrangement
Modifying of manufacturing lines for making engine parts in IKCO and supply chain companies		ü		ü
Change of IKCO assembly line for packing of engine to vehicle		ü		ü
Adjusting supply network for changed and new parts		ü	ü	ü
Altering of after-sale network and supplying of related parts			ü	
New design and engineering knowledge in IKCO, IPCO, value-chain and supply chain			ü	
Changes of responsibilities and organizational structure in IKCO group		ü	ü	ü
Changes in organizational routines, rules and culture		ü	ü	ü
Changing the employment situation and configuration		ü	ü	ü
Change of organization people (management, engineers, technicians and involved people) mentality to local and national products		ü	ü	ü
Change of managers political gains in switching between two artefacts	ü			

Changes in form and arrangement dimensions of artefact require changes in process side of manufacturing and assembly activities in IKCO and supply chain companies. Functional changes affected mainly R&D and product engineering and after-sale activities in IKCO. Each change needs a sort of organizational change in structure, procedures and culture of organization. Political changes were because of material dimension of changes. As it seen from table 6, many organizational changes are formed around the artefact. In other words, artefact addresses different changes in organization and could be the core of analyses, learning and change.

3.4. How artefact hampered organizational learning process at IKCO

Transforming from XU7 engine to EF7 engine requires IKCO to change the cognitive, structural and political aspects. In this case, some of these changes were happened. The negative sides of EF7 case study mainly are places in four areas: delays index both for engine development itself and launch on SAMAND vehicle, lower production ramp-up and replacement rate instead of XU7, higher development investment/cost and higher product price. We explain how changes in artefact dimensions, made cognitive, structural and political issues and hampered learning and change process.

Cognitive areas in this case include different sections. The first one is engineering knowledge and technological capabilities in NPD centre, quality department, product division, supply chain network, and after-sale network. These are product technologies that relate to functional dimension of artefact. Second cognitive area is manufacturing, production and quality equipments and facilities in IKCO auto assembly lines, IKCO engine assembly line, IKCO engine core parts manufacturing lines, engine components plants in IKCO group and network. These are named as production or process technologies.

Considering the above cognitive areas and affected places in IKCO group and network at one hand and four types of changes in engine and its components on the other hand it makes sense that cognitive side of learning process is locked firmly to artefact. As an example, oil pump, water pump and oil coolant system integrated and packed in one place. This change has made serious challenge in engineering, production and supplying of new part. This change required a new and high-level technology both in product and production side. IKCO planned and implemented some projects to technology development and production line installment. Technological gap of old and new components, financial issues and time management made serious problems and caused considerable delay on supply process. As another example new piston ring is high-tech and previous cognitive area doesn't work now. A new component named CVVT has added to engine that needs new knowledge, technology and production facilities that hampered the change process.

Structural areas of artefact change consist of changes in organizational setting at three regions that provide technology and parts and support this change: corporate-wide organization; national-wide supply chain and world-wide network.

Inside the IKCO, this change required the establishment of new companies, changing of responsibilities and new arrangement in structures. As an example the new artefact caused in the establishing a new organization, IPCO, as the responsible for the development of EF7. Because of coordination and integration challenges rooted in organizational change, big hampering happened in the project. Design side of project was successful, but supply side had big delays. At nation-wide level, artefact change needs large changes in supply chain arrangement, making new contracts and cancellation of existing ones. This challenge was also for technology providing and engineering services. World-wide network had also similar changes. New partner entered in IKCO supply chain and also some existent companies should terminate their collaboration.

This dimension is related to leaders and managers of change process. National and organizational culture makes these features act as informal and unclear effect. Political dimension was the most hampering side in this case. Some people have dual behavior on change. They have supporter position in formal documents and official statements but make hard barriers against the change. As an example establishment of new engine production line took several years while similar production line with similar context finished after 1.5 years. Some of them have professional and ethical arguments for their intervention but cannot declare formally. Political environment and national culture expects that large companies to have more commitment to national-level projects and compete again rival foreign companies in challenging way. They prefer projects that are supported and guaranteed by foreign and capable partners. For instance similar project in partnership by Peugeot Company had better results in production line establishment. Some others have personal and unethical approaches on this way. Because of changes in old engine parts supplying contracts, they lose their gains if the change happened. They have informal connection with existent players or formal contracts with IKCO.

As an example similar project with similar changes (XU to TU5 engine) started after XU7 but had considerable progress rather than EF7 project. TU5 partner and technical sponsors were foreign companies (including Peugeot) but in XU7 main players were internal companies and the final responsible was IKCO itself.

This type of hampering is general not for special artefacts. It means that political hampering sees the artefact as presence, as a black-box. It is not sensitive to artefact architecture, modulation, functionality and components.

4. CONCLUSION

Throughout this paper we explored how artefacts can hamper the process of learning. More specifically, we focused on physical artefacts and we identified various links that can be shaped between the materiality, form, arrangement, and function dimensions of artefact on the one hand, and the cognitive, structural, and political aspects of organizational learning on the other. These links can play hampering roles when organizations try to disentangle or loosen them. We also illustrated these findings through an in depth case study. As an important insight emerged out of our empirical study, artefacts might establish different links with hard knowledge (the knowledge about the artefact) and soft knowledge (the knowledge that is not directly related to the artefact). Accordingly, we can hypothesize that a distinction between technical and non-technical knowledge (Kogut 1992) helps us to better understand the hampering impacts of artefacts. In addition, it revealed that although four dimensions of artefact can be differently linked to organizational aspects, there are complex interactions and links between these links. More specifically, the links that are established with the arrangement of the artefact, for example, can highly affect the type and strength of links that its form can shape with organizational aspects. The third theoretical insight refers to the fact that these linkages can directly and indirectly hamper the learning process. For instance, in our data we found ample evidences that political links try to foster further structural links with the artefact in order to distort the learning process.

Using artefact as the unit of analysis in studying organizational learning proved to be functional in various ways. First, we found it much easier to collect data about social dimensions organizational learning when we start from a specific aspect of the artefact and then we explore its links with cognitive, structural, or political aspects. For instance, we could easily communicate with managers by asking how the selection of this new architecture of artefact can reduce the power of some groups or partners. Moreover, focusing on artefact and its links with social aspects, we can also link micro level phenomena, such as daily actions and practices, with macro-level constructs such as power, structure, and collective cognition. Using artefact as the primary unit of analysis is more effective when the context of change is more materialistic where physical objects play more crucial roles than soft phenomena.

Practically, managers not only better make sense of the learning process when it is analysed based on objective and tangible artefacts, but also, they might better understand the implications of the links that artefact has with social dimensions. More specifically, managers can analyse the cognitive, structural, and political implications of changing any dimensions of artefact in order to anticipate possible tensions and barriers.

No doubt this study can be completed using further case studies in different sectors. More specifically, we induce researchers to focus on digital artefacts, such as software packages, which have some physical aspects, as well as significant non-physical dimensions. As we are in the transition from the industrial era to knowledge age, focusing on artefacts as the starting point to identify and study organizational knowledge and its dynamics sounds a fruitful approach to organizational learning which worth numerous future researches.

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