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Spatio-temporal processes of knowledge creation

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ABSTRACT

This article presents a novel spatio-temporal framework for studying knowledge creation. To achieve this, we analyzed the recent literature on space, time and knowledge and conducted an empirical study. The intensive case was about four international distinguished university research groups in Finland in the fields of technology and science. Object, communicative and cognitive spaces with linear and relational times were used as tools for empirical analysis. Combinations of space and time bring out different aspects of knowledge. Knowledge processes of progressing knowledge (time-space), creating distinguished knowledge (space-time), and path-taking and bundling knowledge (spacetime) bind spaces and times closely together. Besides academy, the spatio-temporal framework can be applied to study the knowledge creation processes in art, business and local communities, for example.

1. Introduction

Knowledge creation is a process with spatial and temporal dimensions. Knowledge develops by building on and advancing from what one knows and what others have known. In creative work, ideas are not found, but made through preliminary knowledge and understanding (Flower and Hayes, 1980, p. 21). Knowledge creation is profoundly interactive, as other people and the environment affect the thoughts and actions of individuals. Knowledge is inseparable from the temporal processes of creation, interaction and interpretation as well as from contexts, or spaces, of creation. To understand more about how knowledge develops, it is useful to look more profoundly at how space and time come together in knowledge creation.

This article analyses spatio-temporal knowledge creation processes through theoretical concepts and empirical study. We study how space and time come together to get inside knowledge creation and to understand the knowledge creation processes. The main research questions are *What kind of combinations of space and time exist in knowledge creation?* and *What kind of knowledge processes do these combinations bring out?* We also answer three detailed research questions about the crucial elements for successful knowledge creation in temporally and geographically dispersed research groups. In particular, we ask the following: *What kind of "being there" in space progresses knowledge creation best? How does disrupted, slow and flowing time push knowledge creation forward?* and *At times when knowledge creation advances well, what perceptions of space and time do the members of the research groups share?*

In addition to physical "being there" in the shared geographical location of the group members, knowledge creation progresses best when "being there" extends to the cognitive space of shared understanding and mutual excitement in the group. Knowledge creation does not progress linearly. Temporal disruptions stem from mistakes, frustration caused by a difficult task and disadvantageous coincidences, whereas rigid project organization slows down the progress of knowledge creation and creates a feeling of time passing slowly. During exciting and hectic times when a research group works together in the same place, knowledge creation progresses well and time spent working is not counted – it feels like it is flowing in the background. All these time dimensions are crucial in creating internationally distinguished knowledge, because working through them requires and develops true passion and effort. Although the perceptions of space, time and progression of knowledge creation are individual, temporally these perceptions are shared in a group. Such shared perception emerges through event-bundles that the members of the research groups consider crucial when knowledge creation advances well. These bundles might be a workshop, a positive result of a funding application, and a difficult but successful collaboration task. The bundles collect researchers, artifacts, ideas and concepts together in a temporal way, which clarifies the future path of knowledge creation in a vast knowledge network.

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The concepts of knowledge, space and time are the starting point of the literature review. Therefore, rather than narrowing down the views to these concepts and the relations between them by selecting a certain strand of literature, we let the concepts guide us into the fields of economic geography (EG), organization and management (OM), science and technology studies (STS), and psychology-based research. Based on our review (see Section 2), there are two major challenges in this literature. First, space and time and especially their combinations are rarely addressed profoundly or combined adequately. This happens despite the fact that the studies recognize that space and time matter in knowledge creation, and that interest in addressing space and time has begun to grow (Beyers and Steyaert, 2012, p. 5; Birch and Cumbers, 2010; Brachos et al., 2007, p. 32; Crevoisier, 2004; Gertler, 2003; Hancock, 2006; McCormack and Schwanen, 2011; Nonaka et al., 2006; Powell, 2007, p. 321; Sonnentag, 2012; Vasquez and Cooren, 2013). Space is usually considered a material background and time as universal linear sequences. Second, in addition to the widely recognized importance of interaction in knowledge creation, one should pay specific attention to the cognitive interpretation process, also at individual and group levels. Many earlier studies have challenges analyzing the knowledge creation processes, i.e. the movement of knowledge (Malecki, 2010), sometimes misunderstanding knowledge creation with information transfer (Hautala, 2011a, pp. 50-56). In this view, knowledge is often measured according to its explicit dimensions through statistics on articles or patents, for instance, when the movement process of knowledge can be traced in physical space and linear time. Much of the elements related to the knowledge creation processes are left out, such as tacit and interpreted sides of knowledge and unpredictable coincidences of the creation process. Furthermore, current research often treats the organization as a sum of its individuals (Blaschke et al., 2012; Cook and Yanow, 1993). Therefore, studies in knowledge creation look at the inter-organizational dimension too often without recognizing the intra-organizational variety. In EG, this is one reason why the organization has become a "black box" in knowledge creation (Boschma and Frenken, 2006).

Addressing these challenges is essential when aiming to understand the complex process of knowledge creation for the following reasons. Knowledge is more than information because it is interpreted and exists in a continuum where explicit and tacit dimensions mix. To reveal processes of comprehensive knowledge, one has to adopt a theoretical and empirical framework accordingly. Such a framework addresses three aspects. First, knowledge creation is a process connected to multiple dimensions of time. Comprehensive knowledge is not only connected to linear time but also to relational experienced time (e.g. Csikszentmihalyi, 1997, see Section 2). Second, comprehensive knowledge is contextual and inseparable from multiple dimensions of space (e.g. Vallace, 2011) (see Section 2). Third, as we will show in the results section, within these dimensions, complex and comprehensive knowledge creation addresses many combinations of space and time.

We consider knowledge creation in spatio-temporal processes established in interactive networks in object, communication and cognitive spaces with linear and relational times as explained below (see also Sections 2 and 4). We take the knowledge creation processes as a starting point and show how the interpretation of knowledge into personal mental maps – networks of topics (Blaschke et al., 2012) – is important in those processes as well as group dynamics.

Our spatio-temporal framework of knowledge creation consists of space(s) and time(s) and their combinations. The following dimensions are identified through the literature analysis. *Object space* is the material environment of an individual: what one watches and hears. It provides geographical proximity or distance in the networks of people and laboratories. It focuses on essential objects, such as software, laboratory equipment and research articles used for knowledge creation. Other material settings, such as buildings, chairs and scenery are considered as well. *Communicative space* is formed of one- and two-directional interaction: not only what one watches and hears, but also what one sees, listens and responds to. The communication channels enable interaction between people, for example, through face-to-face meetings, emails, journals, and forums. The difference between communicative space and object space is that the aim of a communication event specifies whether it is one- or two-directional. One-directional communication takes place between an individual and an object. However, a person talking over the telephone is sharing knowledge with another person who has views and opinions, which is why this activity is two-directional even though it also includes using an object. In addition, reading a research article (object) can evolve into two-directional communication through referring to it or discussing it with the author. *Cognitive space* treats knowledge in the form of interconnected concepts, theories and ideas: what one can analyze, understand and discuss when interpreting interaction. It comprises mental models of individuals and shared mental models of groups. In cognitive space, one becomes cognitively closer or more distant. Knowledge is interpreted and justified, which is why knowledge does not exist without cognitive space, or without people. *Linear time* means time where events have sequential order, for instance, through clock and calendar. It also includes the *durée* of the life span of an individual and the *longue durée* of institutional time. *Relational time* is linear time experienced by individuals and groups.

In the empirical analysis of the case regarding international research groups, we indicate how to conduct in-depth empirical research on the knowledge creation processes through the spatio-temporal framework. Our framework with spaces (object, communicative, cognitive) and times (linear, relational) helps to identify three spatio-temporal dimensions in the practices of knowledge creation (see Section 4). The time-space is about linear stages of knowledge progress, the space-time is about flow and disruptions toward distinguished knowledge, and the spacetime is about path creating, bundling and widening for the advancement of knowledge. This framework can be applied to study the knowledge creation processes in many realms, for example in academia, art, business, and local communities. This is of vital interest for various disciplinary and interdisciplinary approaches regarding knowledge and innovation studies as well as for policy and practice in the respective fields. The management of spatio-temporal processes and contexts of knowledge creation is important for knowledge policies.

The empirical study here focuses on a narrow but important field of knowledge creation, namely academia. Around the world, universities are reformed to become more international and entrepreneurial (Etzkowitz and Viale, 2010), aiming at innovations and distinguished knowledge. Recent research confirms that groups outperform individuals in creating novel and innovative knowledge (Amin and Roberts, 2008; Nonaka and Takeuchi, 1995; Singh and Fleming, 2010). Therefore, knowledge is created in enterprises and universities increasingly in groups. Currently, research groups consist increasingly of scholars with different cultural and professional backgrounds who join and leave the groups. Multiple views and skills benefit the novelty aspects of knowledge (Intemann, 2009, p. 261) but such international groups face the opportunity and challenge of diversity (Maddux and Galinsky, 2009). Due to complexity of knowledge creation in international specialized groups, it is suggested to analyze knowledge creation more profoundly, through in-depth case studies dealing with a variety of groups (Bosch-Sijtsema et al., 2011, pp. 276–277; Chen et al., 2010, p. 240; Garcia-Perez and Ayres, 2009, p. 62; Nam et al., 2009, p. 781), as we do in this article. We study distinguished