

Understanding Virtual Objects for Knowledge Creation in Communities

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ABSTRACT

In this paper we investigate the use of virtual objects for knowledge exchange in communities. Information systems provide a wide range of new (virtual) objects for community members which support non-canonical collaboration required for knowledge creation [1,2]. From a sociological perspective these objects are means to cross knowledge boundaries in communities [3]. In our study we extend this aspect by a technical perspective of how virtual objects effectively facilitate activities of knowledge creation. Media Synchronicity Theory [4] proposes how to best accomplish communication performance. It predicts that to achieve effective communication, the two primary communication strategies of conveyance of information and convergence on meaning need to be supported. Building upon this discussion, we examine the use of virtual objects in a dynamic process of knowledge creation. We will draw conclusions on how to appropriately use virtual objects for communication. Our empirical study is based on multiple cases [5] of knowledge communities. Qualitative data has been gathered from the participants of six focused group discussions conducted on a virtual whiteboard which comprises a media choice to interact in real time. The results detail information on the actual use (and not use) of virtual objects (media) for knowledge creation. Based on our findings we empirically confirm the core propositions of Media Synchronicity Theory. We conclude with managerial recommendations on how to employ virtual objects for increasing the effectiveness of dynamic processes of knowledge creation.

Keywords

Knowledge Creation, Knowledge Community, Community of Practice, Collaboration, Virtual Object, Media Synchronicity Theory.

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1. INTRODUCTION¹

The creation of valuable knowledge relies less and less on the geniality of individuals. A steadily increasing amount of information and ultimately knowledge is produced in a highly collaborative manner. As a consequence, organizations try to facilitate the development of communities of practice – networks of actors that voluntarily exchange ideas and are informally bound together by common interest, knowledge and activities [6]. Such communities are dynamic and flexible networks, often residing within a larger organization. They rely on the sustained interests of their members to exchange knowledge and to voluntarily collaborate in problem solving [1].

On the one hand, the creation of knowledge relies on unequally distributed knowledge stocks and problem-solving skills of community members. If everybody had the same information and skills, nothing “new” could be created, hence information sharing would cease. On the other hand, these differences are a threat to knowledge creation, because they impose limits on mutual understanding. Thus, communities are relying on sharing activities in the core and at the boundary which constantly nurture knowledge creation.

Communication technology is a prerequisite to develop and retain the knowledge creation potential of communities. Nowadays, community members are used to rely on communication media, such as telephone, email, real-time message, or video chat. Such communication media represent (virtual) objects that facilitate the creation of knowledge. In particular, because they enable the conveyance of information and the convergence on meaning, and enhance the creation of mutual understanding [4]. Beyond this theoretical proposition, however, we still lack empirical evidence about the interplay of communication media and virtual objects for knowledge creation in communities [7]. We intend to fill this gap by empirically investigating the role of virtual objects in virtual communities. Our study follows the research question:

To what extent are virtual objects contributing to knowledge creation in communities?

In order to investigate this question, the present paper draws on the Media Synchronicity Theory [4]. This theory proposes a

¹ An earlier version of this paper has been presented at the R&D Conference 2014 and profited substantially from the comments of its anonymous reviewers. The paper at hand focuses on the IT-related aspect of the study in order to spur feedback and discussions with the OpenSym community.

framework that explains effective knowledge creation with the fit between the capabilities of virtual objects and the properties of communication.

The paper is structured as follows. In the subsequent section we will review the literature on the core notion of communities, followed by virtual objects, and the applied media synchronicity theory. In the research design section we will present the analysis of a multiple case study we conducted to then showcase our findings on the use of virtual objects in dynamic processes of knowledge creation. These findings will ultimately be discussed and future research will be presented in the final section.

2. RELATED WORK

2.1 Virtual knowledge communities

Knowledge communities have been studied in the context of learning (e.g. [8], innovation (e.g. [9]), and knowledge acquisition and exchange (e.g. [10]). For instance [11] have characterized drivers of learning and knowledge creation in communities. All communities rely on the active participation of community members in collaborative processes of knowledge creation.

Activities of community members across organizational boundaries spark and further new ideas in organizations. In accordance with this, [12] defined communities of practice (CoP) to be particularly effective in (i) *solving problems quickly*, (ii) *transferring best practices*, (iii) *developing professional skills*, and (iv) *helping to recruit and retain talent*. In line with [11] we consider communities as groups of people that share the same mindset and are freely working together online as well as offline. Throughout this paper we thus conceive these active groups practicing knowledge exchange and creation in order to learn and contribute to the group as knowledge communities.

According to [13] knowledge creation in communities takes place in physical as well as in virtual meetings. Therefore, technology is asked to provide the necessary (easy-to-use) tools for interconnecting community members [1,14]. Due to the unequal distribution of knowledge among community members, knowledge can appear to “stick” to one person [15]. In this case, considerable efforts have to be taken in order to transfer the knowledge to another community member [16].

The notion of stickiness can be further explored by knowledge boundaries [3]. Knowledge boundaries occur when actors from differing knowledge domains are conducting sense making. Particularly, the more complex the knowledge exchange is, the more difficult it is to overcome knowledge barriers. According to [17], involved boundaries can be threefold. Syntactic boundaries, e.g. when people use different languages, are fairly simple to overcome. They impede the transfer of knowledge on the level of information processing [18]. Semantic boundaries hinder or distort the translation and comprehension of information: Although one can read a text, one cannot understand it. Finally, pragmatic boundaries, also named political boundaries, arise when conflicting interests are involved. They are of highest complexity and impede “creative” knowledge transformation.

2.2 Boundary spanning in communities

Scholars have noted the positive influence of community members on the knowledge creation potential of a community. For instance Malhotra et al. [19] found trust and diversity of

community leaders (among others) to be effective for the prospering of communities within organizations. Brokers, actors that purposefully connect to other loosely or not connected community members, act in order to fill structural holes [20]. In this paper we aim to analyze the actual act of boundary spanning among community members. We define this activity according to [21] as “*producing a specific type of organizational competence by using and relating capital produced in other fields.* (p. 338)” We conceive this competence as the act of knowledge creation through the active engagement in different knowledge domains. This is of particular relevance since boundary spanners within organizations (members of a knowledge community), are organizational and geographical dispersed.

The acting out of a boundary spanning competence requires a multitude of activities. Those who actively manage information processing across boundaries are to balance between not overloading the organization, and also not cutting knowledge creation. Accordingly, corporate knowledge communities take the role of boundary spanners. Nonetheless, the mediating role of technology has steadily increased. In this paper, technology, in the sense of virtual objects, is suggested to have a prospering effect on boundary spanning. However, boundary spanners need to become acquainted with technology in order to benefit from it. From a technological perspective it is clear that the flow of knowledge within the organization and across organizational boundaries is of importance but prone to failure or bias. Hence, appropriate communication media are needed to lower boundaries.

In this respect, [22] stress the cyclic interaction of boundaries and practices. Community members must be able to engage in specific forms of boundary work and practice work for the good of the organization. Organizations that are relying on communities to develop new products, services and processes are urged to open up traditional boundaries [23]. In this context, communication technology provides the means for boundary spanning, i.e. virtual objects.

2.3 Virtual objects for mutual understanding

We use the notion of virtual objects as proposed by [24]: Any digital artifact that provides a common identity to boundary spanners in order to diminish social knowledge inequalities is conceived a virtual object. In addition, we limit our characteristics of virtual objects to communication media used to create knowledge in the community.

The concept of virtual objects has helped academia and practice to better understand how individuals are collaborating and what “tools” they use to find a mutual agreement.

Because of the relatively open definition of virtual objects, the role of objects can change throughout meetings. Virtual whiteboards, for instance, provide functionalities such as real-time communication, audio/video-chat, text-based communication and others to collaboratively exchange ideas. Community members thus can choose along a variety of suitable objects.

In this study the focus is on virtual objects that are in use. In accordance to [21], who found that virtual objects can be distinguished in “designated objects” and “in-use objects”. We will examine virtual objects that are locally useful, and have a common identity across fields. In the comparative case study of

[21] many artifacts in the collaboration process would fit the definition of virtual objects in theory but few were actually used in practice. However, only objects-in-use are contributing to the creation of knowledge. In the study of [25], for example, multiple cases were analyzed in regards to a series of negotiations. The goal was to reach a mutual understanding in contract negotiations. Their findings suggest that virtual objects are highly relevant for complex and not easy to formulate project ideas. In addition, they claim to conceive virtual objects as multifaceted artifacts that contribute to an established shared understanding. Drawing on this work, we conceive virtual objects as the communication media, knowledge community members engage with.

The scholarly notion of virtual objects creates an understanding on how (IT) artifacts are a means to connect boundary spanners from differing knowledge domains. We thus argue the overarching communication technology is of particular interest since [26,27] are referring to (quasi-)objects as artifacts dynamically living in the IT-environment with the purpose of binding (social) relations.

2.4 Mutual Understanding: The Media Synchronicity Theory

Communication theories explain how media are used to exchange information. The theory of media richness, for instance, describes mutual understanding between individuals using communication media. Daft et al. [28] suggests the richer a communication medium is, the rather uncertainty and ambiguity is reduced. The medium video-conference, for instance, is richer than email, because additional gestures and mimics are transported. Furthermore, Daft et al. [28] hypothesize that communities prefer the richer media over a less rich media. However, [29], for instance, could reject the hypothesis for the case of electronic mail (email) versus voice mail (vmail). People did not prefer the richer medium of vmail over email in case of equivocal situations.

To cope with this shortcoming Media Synchronicity Theory (MST) [4] was introduced. MST does not solely focus on behavioral aspects of actual media appropriation, such as fit to task, media acceptance, social influence, familiarity, training, norms and others [28,30]. It proposes a framework to explain synchronicity, i.e. the state when individuals collaboratively and synchronously work together and process meaning at the same time. Media synchronicity is distinguished in low synchronicity – conveyance of information – and high synchronicity – convergence on meaning. The explanatory power of MST lies in the affordances of communication performance by suggesting a fit between the requirements of the communication process (low versus high synchronicity) and the used media’s capabilities to provide synchronicity. Convergence processes benefit from high synchronicity while conveyance processes do not [31].

2.4.1 Task

In measuring the performance of tasks, media theories explain the effective use of communication tools and the performance of communication in general [4,28]. MST argues that task fulfillment is achieved by matching media to the appropriate communication process.

2.4.2 Two Communication Processes: Conveyance and Convergence

Dennis et al. [4] define conveyance processes as “the transmission of a diversity of new information to enable the

receiver to create and revise a mental model of the situation” (p. 580). According to them, this activity describes the sheer transmission of information. Daft et al. [28], for example, coined this the capability of a medium to reduce uncertainty.

The convergence on meaning is defined as “the discussion of preprocessed information about each individual’s interpretation of a situation.” (ibid.). The objective is the negotiation of mutually agreed meaning.

2.4.3 Media Capabilities

In order to assess the fit between media and communication processes, MST proposes to analyze media according to their capability to enable synchronicity in communication. Based on Dennis’s media synchronicity, MST assesses the information handling capabilities of media according to five physical characteristics: transmission velocity, parallelism, symbol sets, rehearsability, and reprocessability.

Each of the five media characteristics impacts the synchronicity groups can achieve when engaging in media communication. Finally, the fit between the required synchronicity of the communication process and the provided media synchronicity allows predictions about the communication performance that can be achieved.

3. RESEARCH DESIGN

3.1 Research Framework

In our study we particularly aim at examining the effects of virtual objects on knowledge creation in a community.

For this purpose virtual objects in the knowledge creation process are categorized in terms of,

- the level of synchronicity they provide and
- the perceived effectiveness of their use.

By combining these elements, we are able to analyze what level of synchronicity (as represented by a virtual object) is perceived as effective for which act of communication for the purpose of knowledge creation.

Figure 1 depicts our research framework. In accordance with media synchronicity theory, we expect that virtual objects with *low synchronicity* level are most effective for *conveyance of meaning*. Virtual objects with a *high synchronicity* level are most effective for *convergence on meaning*. Vice versa virtual objects with high synchronicity are *not* perceived effective for conveyance and virtual objects with low synchronicity are *not* perceived effective for convergence.

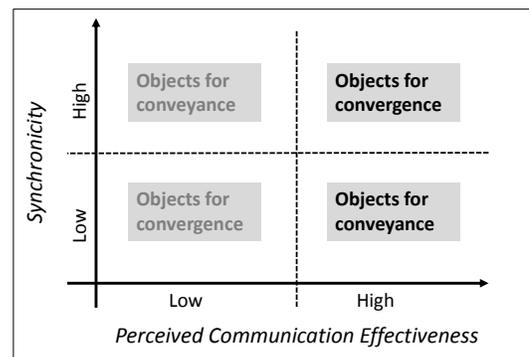


Figure 1: Suggested Research Framework

Throughout the knowledge creation process we intend to find effective virtual objects for communication and cluster them accordingly.

3.2 Research Setting

The empirical study was conducted on a virtual whiteboard (www.rapidmodeler.de) that represents the platform of all available virtual objects. Here, the participants were introduced to objects (functionalities) for chatting, commenting, and posting opinions in order to intuitively use the studied virtual objects. The used virtual whiteboard is browser-based and supports collaboration among all participants in real-time. When the participants felt comfortable on the whiteboard, the topic of the collaboration was introduced to them and they were briefed on the general procedure of the meeting. All community members were asked upfront to prepare the topic of the meeting with three to five arguments in order to have a stimulating and focused discussion.

At the beginning of the meeting, participants were instructed via audio-chat about how to use all the different virtual objects they were provided with. After this preparation, the participants logged in to virtual whiteboard to collaboratively discuss the meeting topics. The participants knew each other as members of their respective community and were familiar with the chosen controversial topic. Meeting (i) *“How can the front-office side of uncv.net [online recruitment platform] and its usability be improved?”*, meeting (ii) *“How can the management and use of uncv.net be improved from a customer perspective?”*, meeting (iii) *“How can advertising tools in uncv.net increase its visibility and search ranking?”*, meetings (iv) & (v) *“What is the impact of smartphones on society?”*.

The moderator of the meeting asked the participants to work on a solution in three steps. First, participants had the task to make their contributions. In a subsequent step all contributions were structured on the whiteboard until the participants were satisfied with the representation. In the closing phase, participants had to mutually agree on one argumentation that best solves the topic of the meeting. All virtual objects on the whiteboard could be used freely by the participants. Hence, it was their individual choice to use a particular object for performing a desired act of communication. The meeting ended when the participants had achieved agreement on a line of argumentation.

The data rests upon one pre-test and five virtual meetings with members of a knowledge community. The meetings lasted on average 1h 20 minutes. As part of this study we observed and interviewed a total of 35 participants.

3.3 Data Analysis

After the meetings we conducted semi-structured telephone-interviews that aimed at determining the appropriateness of the used virtual objects. Interviews lasted in average 36 minutes and were mainly conducted via telephone. Data were analyzed following the deductive theory building approach of [32] in conjunction with an inductive case study approach [5]. In total we recorded 16 h 55 min of audio tape which was fully transcribed and resulted in 135 distinguishable codes and 547 quotations.

4. FINDINGS

4.1 Low Media Synchronicity

The data suggest that in the process of knowledge creation objects with different levels of synchronicity are necessary to

achieve communication performance. As suggested in the earlier section our findings indicate a strong relation of low synchronicity to the activity of idea searching.

“Yes, [in the beginning] was rather a „Just-me-Phase“. Later, I checked how else I can explain my opinion, e.g. with comments.” (ID P30:06; 76:76)

Interviewees perceive the early phase of a meeting as a creative atmosphere where all community members searched for new ideas. Distraction by other participants was disliked. Apart from the qualitative assessment activity logs point to the fact that in the beginning objects must support low synchronicity. For that reason, text-based transmission of ideas is most productive.

“Because the bad thing about doing brainstorming is that everyone would be really interested in what they others are saying and would potentially kill his unique approach” (ID P9:06; 42:42).

Like the interviewee indicates, objects of high synchronicity lead to deep discussions and reduce the creativity of the community. Interview data support that during idea generation the interviewees mainly perform conveyance activities, whereas in the second part of the meetings convergence on meaning is perceived as most important.

As a result, media that support low synchronicity levels were perceived as suitable for transmitting information, particularly at the beginning of the meetings. Namely text-based post-its (code object: post-it) were used for conveying information and named the top mean for idea generating.

4.2 High Media Synchronicity

Our expected findings are also confirmed for virtual objects that provide high synchronicity levels e.g. chatting (code object: chat). These virtual objects were perceived as most suitable for the task of idea selection and development. Participants of the meetings stressed the fact to discuss and understand others' ideas before agreeing on a final solution.

“[...], but in the second phase, I felt that the discussion was really starting, what argument is the most important, and where does it belong to, etc. Well yes, audio is appreciated.” (ID P28:11; 123:123)

The data analysis supports our assumption that media with high synchronicity levels support the convergence on meaning in virtual communities. Also, previously created post-its by others were picked up and used as basis to discuss on the whiteboard (code object: comment-function).

4.3 Media Capabilities

Our empirical findings confirm the media capabilities proposed by Dennis et al. [4]. Media with a low synchronicity level such as email were reckoned as particularly low in parallelism. Real-time-collaboration is evaluated high in transmission velocity and high in parallelism (see also Figure 2: Screenshot from atlas.ti: Media synchronicity code-code matrix).

Real-time collaboration is perceived as very high in reprocessing content. Overall the possibility to get instant feedback and “see” what others are working on contributed not only to the transmission of information but also on the convergence on meaning.

“I think, the whiteboard is an advantage, depending on the group size, [...], if there are more than 3-4 participants, than it

is great, because everybody can see the same situation and can work together synchronously. “ (ID P7:15; 103:103)

For the medium telephone, in contrast, we received many statements of low reprocessability. Interviewee statements indicated that it is hard to follow many new ideas on the telephone and that they preferred to use the medium telephone for convergence on meaning (code object: telephone).

Figure 2 depicts our accumulated findings resulting from the qualitative data analysis derived from the software atlas.ti. The figure shows the perceived effectiveness for communication in terms of two synchronicity levels (low = conveyance; high= convergence) and the assessment of the according virtual object.

	convergence	conveyance	sum:
object: mail	1	11	12
object: post-it	5	20	25
object: real-time collaboration	5	8	13
object: chat	16	4	20
object: comment	2	0	2
object: comment-function	9	1	10
object: links	8	1	9
object: picture	2	1	3
object: post-it attributes	2	1	3
object: telephone	13	3	16
object: video	3	1	4

Figure 2: Screenshot from atlas.ti: Media synchronicity code-code matrix

In line with [33] we find that in the beginning of a dynamic process of knowledge creation media should support the individual creativity of the participants. It is of advantage to not distract people through virtual objects of high richness such as video or audio chats or even discussions. Objects that do not offer or demand instant feedback are preferred in this activity.

However, the need for synchronicity increases with the progress of the meeting. All participants are willing to exchange, understand and connect existing ideas with others to come to create new knowledge. Therefore, with the constant progress of the meeting, objects’ capability of providing synchronicity should increase. Media such as (audio-)chats are perceived as more effective to retrieve meaningful results. Data also show that a constant change in conveyance and convergence activities is happening. We find the media capabilities of high velocity and high parallelism of real-time collaboration (the whiteboard in general) particularly advantageous.

5. DISCUSSION

In this study we strive to show the role of virtual objects within a dynamic process of knowledge creation. In detail, we investigated knowledge communities jointly working on a virtual platform. From a theoretical perspective knowledge creation theory and media synchronicity theory laid the foundation of the empirical analysis [2,4]. Our findings suggest providing knowledge community members with virtual objects for conveyance in the idea gathering stage and with virtual objects for convergence on meaning in the state of agreement.

We can show that communities jointly creating knowledge are using virtual objects in accordance to the communication processes of MST. By this we mean the mixed approach of conveyance of information and convergence on meaning. This communication strategy requires the correct virtual objects to best cross boundaries. In our empirical examination we found that objects with a high level of synchronicity (convergence

strategy) are most suitable for discussing and agreeing. This finding also confirms the media richness strategy [28]. The more ambiguity and uncertainty exists the higher the requirements for the virtual object. We could find that high transmission velocity and parallelism within real-time collaboration support the reduction of ambiguity. Although MST argues that high parallelism reduces the shared focus of participants, we could find that the parallel creation of post-its rather had a stimulating effect on the participants.

On the contrary to idea development, idea generating demands for virtual objects that are low in synchronicity thus focus on the transmission of information. Likewise brainstorming, participants felt in the beginning the urge to submit their individual ideas and opinions to the others. Motivated by the high velocity (simultaneously appearing ideas), virtual objects that just transfer information are most applicable. Richer objects are conceived as distracting in this phase. Members thus felt motivated to be an active and valuable part in the community. Our findings suggest designing virtual objects in accordance to the communication strategy.

In sum, we conducted five virtual meetings within differing topic domains. To further explore the effect of virtual objects in knowledge communities a broader study is suggested. With this we acknowledge a lack of comparability. In future studies a performance assessment in terms of crossing boundaries is suggested. This can be achieved in measuring the three levels of knowledge boundaries as suggested by [17].

6. CONCLUSION

This paper aimed to understand virtual objects in knowledge communities. Based on the Media Synchronicity Theory that describes two communication strategies to achieve mutual understanding, we used the theory to analysis dynamic processes of knowledge creation. Moreover, we found that the hypotheses of MST can be confirmed for the dynamic process of knowledge creation. Virtual objects for conveyance of information are perceived as most effective in the beginning of the process, whereas virtual objects for convergence on meaning are perceived most effective for discussion and agreement.

Based on our findings virtual objects occupy a key role in the virtual meeting. To effectively collaborate, and hence cross boundaries of misunderstanding, meetings should follow the communication strategy of MST. On the one hand, low synchronicity is most applicable in the beginning to avoid distraction and limiting the creative potential of the participants. High synchronicity, on the other hand, is necessary for achieving mutual understanding and agreement in meetings. Virtual objects in the form of (audio-)chats are highly effective in this task.

Managerial implications refer to the set-up of problem-focused meetings. To successfully generate and select opinions in the meeting, participants demand a meeting manager. The manager is very important for supporting, explaining, and guiding the community members through the meeting. S/he should introduce the participants as thoroughly as possible to the procedure and tools of the meeting to avoid any upcoming uncertainty. Our data shows, that the ease-of-use and the few existing functions clearly supported the participants in being creative.

In all the research has extended the understanding of virtual objects in innovation challenges. MST has been empirically tested and provides a strategy on how to use virtual objects in accordance to the dynamic process of knowledge creation.

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8. REFERENCES

- [1] Brown JS, Duguid P. Organizational learning and communities-of-practice: Toward a Unified View of Working, Learning, and Innovation. *Organization Science* 1991;2:40–57.
- [2] Nonaka I. A dynamic theory of organizational knowledge creation. *Organization Science* 1994;5:14–37.
- [3] Carlile PR. A Pragmatic View of Knowledge and Boundaries. *Organization Science* 2002;13:442–55.
- [4] Dennis AR, Fuller RM, Valacich JS. Media, tasks, and communication processes: A theory of media synchronicity. *MIS Quarterly* 2008;32:575–600.
- [5] Yin RK. Case study research: Design and methods. 4th ed. Los Angeles, Calif: Sage Publications; 2009.
- [6] Wenger E. *Communities of Practice: Learning as a Social System*. System Thinker 1998.
- [7] Barley WC, Leonardi PM, Bailey DE. Engineering Objects for Collaboration: Strategies of Ambiguity and Clarity at Knowledge Boundaries. *Human communication research* 2012;38:280–308.
- [8] Wenger E. *Communities of Practice and Social Learning Systems*. *Organization* 2000;7:225–46.
- [9] Franke N, Shah SK. How communities support innovative activities: an exploration of assistance and sharing among end-users. *Research Policy* 2003;32:157–78.
- [10] Lin H, Fan W, Wallace L. An empirical study of web-based knowledge community success. *Proceedings of the 40th Hawaii International Conference on System Sciences* 2007.
- [11] Amin A, Roberts J. Knowing in action: Beyond communities of practice. *Research Policy* 2008;37:353–69.
- [12] Wenger E, Snyder W. *Communities of Practice The Organizational Frontier*. *Harvard Business Review* 2000;January:139–45.
- [13] West J, Lakhani KR. Getting Clear About Communities in Open Innovation. *Industry and Innovation* 2008;15:223–31.
- [14] McDermott R, Archibald D. Harnessing Your Staff's Informal Networks. *Havard Business Review* 2010;March:82–91.
- [15] Brown JS, Duguid P. Knowledge and Organization. *Organization Science* 2001;12:198–213.
- [16] von Hippel E. "Sticky Information" and the Locus of Problem Solving: Implications for Innovation. *Management Science* 1994;40:429–39.
- [17] Carlile PR. Transferring, Translating, and Transforming: An Integrative Framework for Managing Knowledge Across Boundaries. *Organization Science* 2004;15:555–68.
- [18] Shannon CE, Weaver W. *A Mathematical Theory of Communication*: University of Illinois Press; 1949.
- [19] Malhotra A, Majchrzak A, Rosen B. Leading virtual teams. *The Academy of Management Perspectives* 2007;21:60–70.
- [20] Fleming L, Waguespack DM. Brokerage, Boundary Spanning, and Leadership in Open Innovation Communities. *Organization Science* 2007;18:165–80.
- [21] Levina N. Collaborating on Multiparty Information Systems Development Projects: A Collective Reflection-in-Action View. *Information Systems Research* 2005;16:109–30.
- [22] Zietsma C, Lawrence TB. Institutional Work in the Transformation of an Organizational Field: The Interplay of Boundary Work and Practice Work. *Administrative Science Quarterly* 2010;55:189–221.
- [23] Ancona DG. Bridging the Boundary External Activity and Performance in Organizational Teams. *Administrative Science Quarterly* 1992:634–65.
- [24] Star SL. The structure of ill-structured solutions: boundary objects and heterogeneous distributed problem solving. In: Gasser L, Huhns MN, editors. *Distributed Artificial Intelligence Vol 2*; 1989. p. 37–54 .
- [25] Koskinen KU. Metaphoric boundary objects as coordinating mechanisms in the knowledge sharing of innovation processes. *European Journal of Innovation Management* 2005;8:323–35.
- [26] Ekbia HR. Digital artifacts as quasi-objects: Qualification, mediation, and materiality. *Journal of the American Society for Information Science & Technology* 2009:2554–67.
- [27] Kallinikos J, Mariategui J. Video as digital object: Production and distribution of video content in the internet media ecosystem. *The Information Society* 2011;27:281–94.
- [28] Daft RL, Lengel RH, Trevino LK. Message equivocality, media selection, and manager performance: Implications for information systems. *MIS Quarterly* 1987;11.
- [29] El-Shinnawy M, Markus ML. The poverty of media richness theory: explaining people's choice of electronic mail vs. voice mail. *International Journal of Human-Computer Studies* 1997;46:443–67.
- [30] Davis FD. Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly* 1989;September:319–40.
- [31] Murphy P, Sabharwal A. Design, Implementation, and Characterization of a Cooperative Communications System. *IEEE Transactions on Vehicular Technology* 2011;60:2534–44.
- [32] Eisenhardt KM. Building Theories from Case Study Research. *Academy of Management Review* 1989;14:532–50.
- [33] Jones Q, Ravid G, Rafaeli S. Information Overload and the Message Dynamics of Online Interaction Spaces: A Theoretical Model and Empirical Exploration. *Information Systems Research* 2004;15:194–210.