Knowledge Creation Across Boundaries: Innovative Work in Software Development

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Abstract

How does the current increase in connectivity impact the sharing of knowledge, and the creation of new knowledge in the form of innovation? The ability to coordinate and manage people separated by numerous boundaries – functional, cultural, occupational, geographical – is essential to knowledge creation and innovativeness (Dougherty, 1986; Bechky, 1999; Carlile, 2001). New information technologies such as the Internet are challenging old notions of distance and boundaries because they permit instant connectivity across many areas of the globe. Boundaries are becoming more permeable, as new regions can become participants in global activities, and as dispersed teams proliferate.

The paper is based on an ethnographic study of work practices and coordination in a dispersed team of software developers. The software industry's digital and modular character makes it an opportune setting for the study of knowledge creation across space. In theory, software could be developed anywhere and transmitted quickly and intact. At the same time, software retains, in spite of important efforts to transform it into a routine activity, a non-trivial craft and creative quality (Cusumano, 1991; Glass, 1995). Over a period of seven months, I was a participant-observer in a software team in the process of developing a new product through cooperation between two sites: one on the West Coast of the US and one in Bangalore, India. The wealth of observation, interview, and archival data gathered was analyzed according to the grounded theory approach recommended by Glaser and Strauss (1967). The paper shows that it is the limited availability of boundary spanners, and

the absence of boundary objects that support concrete and interactive encounters, that form the impediments to the creation of knowledge in a dispersed setting.

Boundary objects are objects that "inhabit several intersecting social worlds and satisfy the information requirements of each of them" (Star and Griesemer, 1989: 393). The boundary objects used in the project – computer screens, documents, whiteboards – were destined to facilitate the cooperation of developers across distance. However, the distributed environment limited severely the use of the most interactive boundary objects – computer screens and whiteboards.

The importance of boundary spanners to the efficient operation of organizations has been long documented (Allen, 1977; Tushman, 1977). However, there were only few individuals who traveled between the project's sites. The most important category of boundary spanners were the Indian developers who came to work at the US site and could explain the rationale for the code written in India, as well as interpret and translate requirements and work for the two sites.

By far the most successful and productive knowledge-creation interactions involved face-to-face encounters involving boundary spanners and a focus on boundary objects that allowed the visualization and transformation of the abstract entities that form the object of software writing. Often, engineers would work together in front of a computer screen or around a whiteboard. For example, a developer would walk in a colleague's office, go straight to the whiteboard, and state before starting to draw: "I need to verify my understanding." By expressing their abstract ideas concretely and visibly, developers can then further discuss their assumptions, examine the possible solutions, and look for ways to improve them. As the knowledge is concretely represented and transformed by means of a boundary object, others can intervene by offering suggestions. Furthermore, workers can sustain an intense engagement with the work and with one another once their encounters are focused around such concrete and interactive objects (Goffman, 1961).

Thus, the conjunct use of boundary spanners and boundary objects achieves two main goals. First, it leads to the development of coordination routines. For example, because the product of work is visible on a whiteboard or on a computer screen, developers can make use of laconic verbalization to achieve effective coordination. Second, the conjunct use of physical presence with the use of concrete and interactive boundary objects allows the

transmission of much more than information on the specific problem to be solved. The path used to find and fix problems and bugs becomes also visible, as well as are the discarded options. This conjunct use gives developers a sense of one another's competence, work style, and engagement with the project. In turn, this knowledge has positive effects on their willingness to participate in future coordination among sites.

However, across dispersed sites, such development of routines and such awareness of the remote developers' identity were severely impeded by the absence of interactive boundary objects like whiteboards. At the same time, the limited availability of boundary spanners reverberated and affected the effectiveness of existing boundary objects. Thus, the paper identifies the impediments to knowledge creation across distance at a degree of specificity that allows and invites managerial action to correct them. At the same time, software design and production are activities common to many industries. As the content of work continues to shift from material processing to knowledge creation, the finding pertaining to the software industry will reflect broader changes that are occurring in the workplace generally.

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