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Weak information work in scientific discovery

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Abstract

Scientists continually work with information to move their research projects forward, but the activities involved in finding and using information and their impact on discovery are poorly understood. In the Information and Discovery in Neuroscience (IDN) project we investigated the information work involved as researchers make progress and confront problems in the practice of brain research. Through case studies of recent neuroscience projects, we found that the most difficult and time-consuming information activities had parallels with Simon's explication of weak methods in scientific problem solving. But, while Simon's weak/strong distinction is an effective device for interpreting information work, his general conception of how discovery takes place is artificially constrained. We present cross-case and case-based results from the IDN project to illustrate how the conditions of problem solving Simon associated with weak methods relate to information work and to identify additional weak aspects of the research process not considered by Simon. Our analysis both extends Simon's framework of what constitutes the discovery process and further elaborates how weak approaches influence the conduct of research.

Keywords: Scientific discovery; Information practices; Information seeking; Neuroscience; Research processes

1. Introduction

Information is an essential resource in the process of scientific discovery, and scientists are continually working to gather information from the literature, databases, web resources, and colleagues. In turn, they evaluate, collect, manage, consult, integrate, and apply that information to move research forward. This ''information work'' has never been assessed on the large scale in terms of time spent or impact on the advancement of science. But, its importance is evident in the number of scientific researchers and information scientists striving to find better ways to mobilize and work with the ever growing body of information resources. In the Information and

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Discovery in Neuroscience (IDN) project we investigated the information work involved in the practice of brain research (Palmer, Cragin, & Hogan, 2004). We found that the most difficult and time-consuming activities paralleled Simon's explication of weak methods in scientific problem solving.

As discussed by Simon, Langley, and Bradshaw (1981), weak problem solving is associated with specific research conditions, including an ill-structured problem space, unclear or unsystematic steps, and a lack of prior domain knowledge. Conversely, strong problem solving is applied when a research problem is well defined, and it tends to proceed through systematic, routine activities and with a high level of domain knowledge. Strong, expert methods are practiced in what Kuhn (1962) referred to as normal science. Revolutionary, paradigm-altering science, on the other hand, advances with methods that have not been refined for the given application. While "crude and cumbersome" these weak approaches are not a second-best choice for solving research problems but rather "may be the only ones at hand on the frontiers of knowledge, where few relevant special techniques are yet available" (Langley, Simon, Bradshaw, & Zytkow, 1987).

In our analysis of information work in the practice of brain research, Simon's distinction between weak and strong approaches proved to be an effective device for interpreting the activities involved in finding and using information. However, we found Simon's more general ideas about the process of discovery to be artificially constrained. Thus, our results extend Simon's conception of what constitutes the discovery process while further elaborating how weak approaches influence the conduct of research. In this paper, we begin by introducing the literature on scientific discovery and problem solving that informed our analysis and by describing our case study methods. Based on our cross-case analysis, we discuss our conception of weak information work (WIW), the prominence of WIW in certain stages of research, and its role in specific modes of information seeking. Two short case studies are presented to provide a more detailed illustration of how the conditions Simon associated with weak methods extend to information work. We conclude by arguing that understanding the dynamics of weak and strong information work is important for determining how information systems and services can make the greatest contribution to the discovery process.

2. Background

2.1. Conceptions of discovery

The mechanisms of scientific discovery have been characterized from different scholarly perspectives. Practicing scientists have written about the process of discovery to raise the awareness of others involved in the scientific enterprise and the interested public (e.g., Root-Bernstein, 1989). Historical accounts are most numerous, with many authors concentrating on the complex and esoteric nature of science or particular high-profile events (e.g., Bernal, 1953; Harwit, 1981; Holton, 1973). Kuhn's (1962) influential book distinguished revolutionary science from "normal" science, providing a more socially based interpretation than many earlier works. He situated significant research advances in the context of the larger landscape of activities that build and sustain scientific paradigms and disciplines.

Few information scientists have conducted empirical investigations of the discovery process for application to information service and system development, although Bawden's (1986) discussion of the connection between creativity and information strategies is worthy of note. He recommended certain information technology features for enhancing creative problem solving and discovery, such as access to peripheral material and explicit representation of analogies, patterns, and exceptions. Similarly, Martyn (1974) argued that the information needed to formulate and solve problems often lies outside of the core material that supports professional competencies and may not appear immediately relevant.

Cognitive science has contributed much to our understanding of scientific thinking. Dunbar's work (e.g., Dunbar, 1993) in particular has interesting implications for information systems. For example, his finding that the setting of goals impacts the discovery of new concepts suggests that particular kinds of information could assist scientists in reworking goals as new evidence or inconsistent findings emerge. Other scholars have recognized the importance of information in the discovery process. Newell (1969) identified information acquisition as an important but strictly cognitive component of discovery. Fujimura (1987) accounted for certain types of information gathering and exchange in articulation work—the collecting, coordinating, and integrating tasks that make research projects "doable".