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An Interactionist Approach To Complexity in Computer-Supported Knowledge Work

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Introduction

The nature of computer-supported work varies widely, from settings in which the employee's total task is completed through the use of information technology, to settings in which the employee must determine how and when to use one or more technological tools in task performance. In the latter situation, the employee may be a knowledge worker already confronted with a difficult, non-routine task that requires significant cognitive effort and in which the knowledge worker is expected to apply his or her own knowledge capital (Davis et al., 1993).

What impacts are expected from high complexity work settings like the use of information technology (IT) in knowledge work? The research on work redesign has focused on increased task complexity as beneficial, and has found that changes in the work setting that increase workers' perceptions of task complexity are related to increased motivation, satisfaction, and in some cases, performance (Griffin, 1991). Other researchers have found negative impacts of high complexity work (Banker et al., 1993; Schroder et al., 1967). However, research also shows that some of the negative impacts of high complexity work can be mitigated by increasing the level of cognitive information of an individual (Campbell & Gingrich, 1986; Khalil & Clark, 1989).

These seemingly conflicting results suggest that the relationship between high complexity work and task outcomes is neither simple nor deterministic, and that the interplay between individual differences and the work setting are key to understanding the relationship. When MIS provides IT support for high-complexity knowledge work tasks, it may need to consider the characteristics of that IT, how that IT may interact with the knowledge worker's tasks, as well as the users' capabilities in order to predict outcomes like performance and satisfaction. The purpose of this paper is to (1) integrate the existing literature on complexity and (2) describe an interactionist model of complexity which attempts to include the various elements of complexity. The interactionist model of complexity is a framework that can be used to enhance our understanding of complexity in the context of computer-supported knowledge work, and support research on the relationship of complexity to important organizational outcomes.

Definitions of Complexity

Complexity is commonly conceptualized as an attribute of individuals or the work setting. Complexity has been studied as an objective characteristic and as a subjective

reaction to characteristics of work. In addition there is some research that examines how task, person, information technology interact.

Complexity as Objective Task or Person Characteristic

Much research has been done on objectively defining task complexity (Simon, 1978; Schroder et al., 1967). These definitions focus on an analysis of the task independent of the task performer. For example, Wood (1986) conceptualizes complexity as a function of the number of task components (component complexity), the number of interrelationships between task components (coordinate complexity), and the extent to which those components change over time (dynamic complexity). This definition is based on the idea that increases in any one subtype of complexity places additional cognitive processing demands on the task performer.

One of the most prevalent approaches to objectively defining 'person' complexity is the area of cognitive complexity. This perspective states that there are important differences between individuals based on how they process information, in particular individuals' ability to differentiate and integrate parts of any information stimuli (Schroder et al., 1967). While cognitive complexity relates to the way information is mentally processed, a related concept, mental models, addresses the contents and use of stored knowledge. One type of mental model is a device model, which represents one's knowledge of how a system or device behaves; a second type of mental model is a task model, which represents a user's knowledge of how to carry out a task. Research has shown that the existence of mental models results in increased learning of systems (Kieras & Polson, 1985) and retention of system knowledge (Kieras & Bovair, 1984).

Two main advantages of objective definitions of complexity are measurement and control. The definitions of complexity discussed in this section identify the specific task characteristics or levels of a person's processing or knowledge that are related to higher or lower levels of complexity. This means that complexity of task can be measured separate from other parts of the work setting and from individual task performers. Also, the task performers' complexity of processing and knowledge can be measured to understand individual differences in working with complex tasks. It also means that we know how to manipulate task characteristics in order to study the impact of changes in level of complexity.

Complexity as Reaction to Task or Technology Characteristics

Some research on complexity has described task and technology complexity as an individual's perception of difficulty. Tait and Vessey (1988) define system complexity as the system designer's perceived difficulty of determining system requirements and performing system design. In effect, technology complexity was operationalized as perceived task difficulty. This approach is consistent with the work redesign literature that has traditionally measured employees' perceptions of their work setting and related those perceptions to job satisfaction and performance (Griffin, 1991).

Research on perceptions of complexity is implicitly interactionist, since the measure captures the individual's response to the work environment. Such perceptual measures, however, provide no information about how the perception stems from particular aspects of the work environment or of the individual. Such a "summary" measure may be useful to verify how well measures of the objectively-defined task and person characteristics predict perceptions of complexity.

Complexity as an Interaction

Several researchers have taken an interactionist approach. For example, previous research has examined complexity as an interaction between (1) person and task characteristics (Campbell & Gingrich, 1986; Fletcher et al., 1992), (2) person and technology characteristics (Banker & Slaughter, 1994), and (3) task and technology characteristics (Meyer & Curley, 1991). Studies examined in this category have generally been limited to considering two-way interactions in isolation from any conceptual model of the whole work process, and few advanced a theoretical basis for their measures of task or technology complexity.

Limitations of Current Research

While there has been much research in individual areas of complexity, it has not been framed by a conceptual model that accounts for all critical aspects of computer-supported knowledge work; namely task, people, and IT characteristics. Such a model would need to include the complexities of the task being supported, the IT being used, the person performing the IT-supported task, as well as the relationships of these individual complexities to each other, and to outcomes. There is also a need to develop a conceptualization of IT complexity.

Our research seeks to address these limitations. In addition we lay the foundation, via theoretical propositions, for addressing the two key needs: (1) the empirical validation of the conceptualization of complexity, and (2) tests of the relationship between complexity of the work setting, knowledge worker, and work outcomes.

An Interactionist Perspective on Complexity

We propose an interactionist approach to modeling complexity in computer-supported knowledge work, based on the human information processing theory (Schroder et al., 1967) and Bandura's (1983) model of reciprocal determinism. Our model (see Figure 1) portrays perceived complexity as an interaction between the person (knowledge worker) and the environment (task and technology), which produces certain behaviors (e.g., performance).

In computer-supported knowledge work, the sources of complexity in the Environment include task, technology and the interaction between task and technology. While the nature of task complexity has been examined in the literature, there is no comparable conceptual model developed for IT complexity. We propose using Wood's (1986) model

of task complexity as a framework to model IT complexity. Given the frequency of change in IT, we argue that a taxonomy should be based on how technology affects human information processing, and not the characteristics of currently available IT.

The Person component of the model represents individual differences in the ability to deal with computer-supported knowledge work. These differences can be described in terms of cognitive complexity and by the nature of individual's mental models. We theorize that complexity in computer-supported knowledge work arises from the interrelationships between the task and IT, and between this task-IT dual task setting (environment) and the person:

Proposition 1.

A significant relationship exists between person and environment complexities and one's perception of complexity.

The task-IT interaction can also be a source of complexity; for example, complexity can stem from differences between task structures and the pattern of IT operations. Previous research has hypothesized that the more one's task model resembles his/her device model for the task, the less cognitive burden required to use the IT in support of the task (Kieras & Polson, 1985). Therefore, we can form the following proposition:

Proposition 2. The more one's task knowledge resembles one's device knowledge for that task, the lower one's perception of complexity.

The Behavior component of the model represents the knowledge worker's response to interaction with the knowledge work environment. Examples of this behavior include performance on tasks, usage of IT, and resistance to IT. Empirical research has found a positive relationship between cognitive complexity and performance (Campbell & Gingrich, 1986; Khalil & Clark, 1989), and between the existence of mental models and performance (Kieras & Bovair, 1984). Further, environment complexity has been shown to impact performance in a curvilinear fashion (Schroder et al., 1967). Thus, the following proposition is offered:

Proposition 3.

A significant relationship exists between person and environment complexities and one's level of performance.

Obviously there are many other interesting propositions that emerge from the interactionist model, but space does not allow a full listing. These three, high level propositions are offered as examples of some of the first relationships that will be explored in this research stream. Later, additional research questions will be investigated; in particular, how past behaviors interact with the person (e.g., learning by building mental models or by increasing levels of processing) and with the environment (e.g., adaptive technology systems).

Advantages of an Interactionist Perspective of Complexity

A key advantage of the interactionist perspective is that it more closely matches the dynamics of real world organizations than situationist perspectives (Schneider, 1983). In computer-supported knowledge work, it isunrealistic to study the impacts of complexity on individual or organizational outcomes without considering the characteristics of the computer (IT), the knowledge work (task), and the knowledge worker (person). Several theories that examine the role of IT in organizations have advocated the identification of IT, Task, and Individual/Organization characteristics and how they interact to affect outcomes (DeSanctis & Poole, 1994; Orlikowski, 1992). Because of its closer match to organizational dynamics, the interactionist perspective can be expected to provide better predictive and explanatory power for behaviors such as IT usage, performance, and resistance (Markus, 1983). Finally, the interactionist model of complexity integrates the various approaches to complexity found in multiple disciplines. As such, it provides a comprehensive framework which can be used to organize and guide further research on complexity.

Conclusions

In the paper we present a conceptual model for complexity in computer-supported knowledge work based on theories of Human Information Processing and Reciprocal Determinism. Based on this model we discuss a research agenda that includes both validation of measures of person, task, and IT complexity as well as some more specific propositions about how complexity of person-task-IT interacts to impact behavioral outcomes like performance. Our goal is to extend current research on complexity by presenting a theory-based model which can be used to study complexity from a variety of perspectives, while accounting for the presence of other key contributors to complexity.

A full paper with references is available from the authors upon request.

Figure 1. Interactionist Model of Complexity in Computer-Supported Knowledge Work

Figure not available. Contact author.