Paradigms Of Information System Design

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ABSTRACT

The paper presents a review of design theories, derived from CIS, HCI, CSCW, and Organizational Science literatures. It is argued that newer models of design address the deficiencies of current models of design, that focus on design *closure*. The focus on closure de-legitimizes the essential activities of investigating, negotiating and formulating requirements for an effective design. IS design faces five "problems" that need to be resolved:
(i) employing an effective model of design by with which to manage the labor process,
(ii) defining the role of the information system,
(iii) bounding the organizational locus of the system problem,
(iv) understanding the cultural, social and business context of which the IS will be a part, and
(v) managing collaboration between cross-functional stakeholders.

KEYWORDS:
Information System Design, System Development Methods, Co-design of Business and IT Systems

1. The Design of Organizational Information Systems

Business organizations are increasingly moving their focus 'upstream' in the traditional, waterfall model of the system development life-cycle. Recent trends in information system implementation - standardization around a small number of hardware and software environments, the adoption of internet communication infrastructures, object-oriented and component-based software design, outsourcing and the use of customized software packages - have standardized and simplified the design and implementation of technical systems. Organizational information systems are no longer viewed as technical systems, but as organizational systems of human activity - business processes, information analysis and dissemination - that are supported by technology. Firms can therefore focus more on the strategic and organizational aspects of information systems, implementing cross-functional information systems that affect stakeholders from many different organizational and knowledge domains.

Yet existing approaches to information system design derive from a time when *technical* complexity was the core problem: so they are intended to bound and reduce the organizational 'problem' so that a technical system of hardware and software may be constructed. Existing design approaches treat complex organizational information systems as synonymous with information technology. They are based on models of individual, rather than group, problem-solving and cognition. We have few methods to enable stakeholders from multiple knowledge domains to participate in information system design. What methods exist are ad hoc and not based upon any coherent theoretical understanding of how collaborative design works. We have no models upon which to base future management approaches and methods for 'upstream' (from the waterfall model of the traditional, technical system development life-cycle) information system design. Information system design tends to be viewed as a single stage in the system development life-cycle, concerned with the detailed "laying out" of system software - more akin to technical drawing than to design in the sense used in other fields, such as architecture. The intent of this paper is to retrieve the notion of design and to view design as an holistic activity, where form is conceptualized for a whole set of information system elements, some of which are physical and some abstract in nature. Every information system design process is unique, because every information system is embedded much more firmly in an organizational context and culture than physical artifacts. To manage this uniqueness, we need a more complex understanding of what design involves than that communicated by most IS perspectives.

Winograd & Flores (1986) define design as “the interface between understanding and creation”. Unsurprisingly, given the difficulty of studying such a complex process, there are few models of design which are based upon empirical work, rather than theoretical conjecture or controlled experiments. Most models are also rooted in an individual perspective of design, rather than those group processes which occur in most IS design contexts.

As theories of design activity have evolved, so the definition of the term "design" itself has changed. In the information systems literature, design was initially viewed as the decompositional processes required to convert a structured IT system definition into a physical system of hardware and software. In the introduction to Winograd (1996), the author states:

> " Design is also an ambiguous word. Among its many meanings, there runs a common thread, linking the intent and activities of a designer to the results that are produced when a designed object is experienced in practice. Although there is a huge diversity among the design disciplines, we can find common concerns and principles that are applicable to the design of any object, whether it is a poster, a household appliance, or a housing development." *(Winograd, 1996, page v).*

Given these commonalities, we have to question why the design of an organizational information system is so much more problematic than the design of a physical artifact, such as a house. In the field of architecture, design has well-established principles and procedures, with established computer-based tools to support them. Yet information system design is often viewed as a single stage in a "structured" system development life-cycle, concerned with the detailed "laying out" of system software - more akin to technical drawing than to design in an architectural sense. The intent of this paper is to retrieve the notion of design and to view design as an holistic activity, where form is conceptualized for a whole set of information system elements, some of which are physical and some abstract in nature (for example, a particular approach to the management of organizational change, the physical information system's suitability for a particular group of users, or to its ability to provide a set of flexible organizational outcomes for a range of different stakeholder groups). For the purposes of this discussion, design is viewed as the process of conceptualizing, abstracting and implementing an organizational information system, rather than as a specific stage in the information system development life-cycle. Design is not viewed as giving form to system software, but as giving form to a whole set of information system elements, some of which are physical and some abstract in nature. The abstract elements may lead to such deliverables as a particular approach to the management of organizational change, the physical information system's suitability for a particular group of users, or to its ability to provide a set of flexible organizational outcomes for a range of different stakeholder groups. Every information system design process is unique, because every information system is embedded much more firmly in an organizational context and culture than physical artifacts. Abstraction and generalization are therefore much more complex than that required for a universal artifact that can be employed in many different concepts.

2. Categories of IS Design Research

This paper draws on several literatures to derive an understanding of what design "in the round" means. Abstractions of design from the literatures on computing and information systems engineering design, human-computer interaction, computer-supported cooperative work, management information systems and organizational design are synthesized here, to present an holistic conceptualization of design as organizational problem-solving, individual and group activity, and management-oriented process models. For the purposes of this discussion, design has been divided into eight detailed categories, summarized in Table 1.

Table 1: Categories of Design Theory

Category	Theoretical Basis	Focus	Exemplar Studies
Design science studies of the design process	Simon's (1996)"science of the artificial	The specification and modeling of a form for the technology artifact. ", Focuses on activities for a single (design) stage of the systems development life-cycle (SDLC)	(Walls et al., 1992; Walls et al., 2004)
Design science studies of the design product	Simon's (1996)"science of the artificial	Examine how properties of system form affect system function. Focused on technical properties of component design.	(Hevner et al., 2004)
HCI and CSCW experiments with methods and techniques to achieve specific artifact properties	Norman's (1990) psychology of everyday things; Theories involving support for communities of practice (Brown and Duguid, 1991; Lave and Wenger, 1991)	Constructing usable systems for specific applications of technology, often with a focus on support for collaboration in community environments	(Brown and Duguid, 1992; Muller, 2002; Winograd, 1997)
HCI and CSCW research into impacts of design properties	Theories developing approaches to interaction design (Preece et al., 2002; Winograd and Flores, 1986) and ethnographic approaches to design (Dourish and Button, 1998)	Mainly field studies of impact of design properties that make systems usable or provide the basis for collaboration.	(Corbett, 1992; Dourish, 2001; Dourish and Bellotti, 1992; Winograd, 1997)
HCI and CSCW research-through-design into artifact or community environment properties for specific applications	Activity theory (Vygotsky, 1978); Situated action (Suchman, 1987); Distributed cognition (Hutchins, 1991, 1995);	The properties of system form that make systems usable or suitable for various applications. Mainly focused on collaboration or interaction with wider knowledge sources.	(Engestrom and Middleton, 1998; Greenbaum and Kyng, 1991; Martin, 2004; Nardi, 1995a, b; Star, 1998; Suchman, 1998, 2005; Wenger et al., 2002)
MIS, HCI, and CSCW research into user-involvement in design methods and processes	Theories related to user participation and involvement (Barki and Hartwick, 1989; Kappelman and McLean, 1992)	Studies concerned with user involvement in design.	(Barki and Hartwick, 1994; Baroudi and Ives, 1986; Gasson, 1995; Howcroft and Wilson, 2003; Torkzadeh and Doll, 1994)
Organizational MIS or CIS Studies of design process research	Situated action (Suchman, 1987); Punctuated equilibrium (Gersick, 1991); Design as co-evolution of problem and solution space (Maher and Poon, 1996)	Focusing on field studies into alternative process models of design, in terms of situated and/or collective action. Some studies refer to this as "early requirements analysis."	(Bergman et al., 2002; Dorst and Cross, 2001; Lyytinen and M., 2006; Truex et al., 1999)
Organizational MIS or CIS Studies of design product research	Star's theory of boundary objects (Bowker and Star, 1999; Star, 1989); Weick's (1995; 2001) theories of organizational sensemaking	Focusing on field studies into organizational impacts of design-as-situated action.	(Carlile, 2002, 2004; Gasson, 2005; Levina and Vaast, 2005; Pawlowski and Robey, 2004)

The eight detailed categories identified in Table 1 translate to four high-level categories, relating to different foci and assumptions about design methods in practice, research paradigms, and the impact of IS on organizational practice.

Design science studies

Design science studies are influenced heavily by Simon's (1996) "sciences of the artificial.", They are therefore heavily predisposed to focus on properties of a technology artifact, or methods to achieve desired properties. Because of the emphasis on technology, there is a dominance of studies that focus on activity at a *single* stage of the systems development life-cycle (SDLC), dealing with the specification and modeling of a *form* for the technology artifact to be produced. Design is therefore treated as synonymous with modeling, at the analysis stage of Simon's ill-structured problem resolution, ignoring the (much less structured activities required to structure the problem and to identify criteria by which to choose between alternative forms of a solution.

HCI/CSCW research into properties of usable collaboration systems

The next three categories focus on three forms of research that are concerned with properties of IT systems that make them usable by specific individuals or groups. One focus of this research is to experiment with design methods and techniques to achieve specific artifact properties. A second is to study the impacts of specific IT artifact or community environment design properties on their use. The third focus is to conduct research-through-design into the properties of UT artifacts or community environments, that make them suitable for specific applications.

MIS, HCI and CSCW research into user-involvement in design

The third category of design research grew out of an HCI interest in encouraging user participation in design. Now found in the MIS, HCI, and CSCW literatures, such studies often widen the base of participation to study approaches to ensuring effective stakeholder involvement in the design of information systems (systems of information creation and transfer that may or may not involve new forms of technology).

Organizational MIS/CIS Studies of design process and products

The final category focuses on the processes and products (impacts) of design-as-situated action.. Some studies are labeled as studies of "early requirements analysis", to coexist with the use of the term 'design' in the computing and IS field to refer to a single stage of the SDLC. They largely call on organizational theories that explain how collaborative action may be supported across boundaries of time, space, organizational structure, or knowledge domain.

3. Limitations Of Current Design Practice Arising From The Various Literatures On Design

It would appear, from the review presented here, that older design theories – and those that are primarily concerned with properties of a technology artifact – focus on design problem *closure*. While this may have been appropriate at a time when information technology designers were concerned with relatively well-defined, unitary problems, it is no longer appropriate for groups of designers engaged in the exploration and definition, as well as the solution of, "wicked" problems relating to organizational information systems. The problem of "the problem" dominates design theories and yet design models are concerned more with solution definition than with problem investigation. Given the concerns expressed above, coupled with the limitations of human cognition, it would appear that evolutionary models of the design process are more appropriate for "opening up" the design problem and that more recent models of design process and product concerns address this interest specifically.

I end with five areas of concern, that limit current conceptualizations of design. As with any complex problem, these five areas may be conceptually separated, yet are interrelated.

1. *The labor process problem:*

   While the traditional model provides a clear basis for managing the labor process in IS development, it artificially separates the conceptual and social processes of organizational IS development which are referred to here as design processes. Design activity cannot be separated into a single stage of the system development lifecycle, as in the traditional model: requirements specification, design and technical system implementation are intertwined (Bansler and Bødker, 1993) and so require support and legitimacy at all stages of the system development life-cycle. Radical redesign of a technical system may occur even at the system implementation stage, when problems are encountered during interactive user testing; such redesign is often referred to euphemistically as 'system maintenance' (Lientz and Swanson, 1980).

2. *The design process-model problem:*

   The way in which design is managed is based upon a decompositional, breadth-first exploration of the design problem, where all requirements for a solution are defined before problem decomposition is attempted. But empirical studies of individual design strategy show that design strategies are "opportunistic" in nature, adopting depth-first, iterative, recursive or 'inside-out' approaches (Ball and Ormerod, 1995). Turner (1987) argues that "requirements and solutions migrate together towards convergence". Designers fit known solutions to parts of the problem, or reframe the problem to fit known solutions (Malhotra (Dorst, 2006; Dorst and Cross, 2001; Guindon, 1990; Malhotra et al., 1980).

3. *The bounding problem:*

   The traditional model presupposes a design problem which is unitary in nature, which exists independently of the designer's frame of reference and which is capable of analysis under conditions of "bounded rationality" (Simon, 1973), where the designer bounds the problem until it is amenable for structured analysis. But the design of complex organizational information systems centers upon the investigation of socially-constructed, "wicked" problems (Rittel and Webber, 1973), which are associated with interrelated, organizational systems of activity. Such problems cannot be "stated" or "solved" in the sense of definitive rules or requirements for a solution (Moran and Carroll, 1996): they are socially-constructed and subjective (Galliers and Swan, 1997; Schön, 1983) and each problem is interrelated with – and thus cannot be defined separately from – multiple, other organizational problems (Rittel, 1972).

4. *The collaboration problem:*

   The traditional model of IS design is based upon an individual, cognitive model of problem-solving and so excludes many necessary social processes required for collective investigation and negotiation of design attributes. Empirical studies indicate the centrality of communication, shared learning and project co-ordination, but such processes are often deemed illegitimate by managers guided by traditional, individual models of design (Curtis et al., 1988; Walz et al., 1993). Existing approaches resolve this problem by assuming that a unitary, intersubjective model of the designed system can be negotiated by design team members. As we have argued above, this may not be feasible in most organizational information systems supporting complex human work-systems, as these problems are "wicked" problems (Rittel, 1972), that are socially constituted, represent multiple work-goals and are highly interrelated.

5. *The context problem:*

   The traditional model ignores the context of design, as situated in a socially-constituted organizational culture. The form taken by a design involves both technical and social issues,

for example, designers may debate the form of a technical artifact in terms of whether users should be prevented by its design from amateur repairs, or whether its design should reflect users' desires for conspicuous consumption (Callon, 1991). Design is also political: an information system may change the nature of work and the basis of power, for different stakeholder groups within an organization (Wilkinson, 1983). Design processes are viewed as irretrievably interrelated with context: design activity is "situated" in knowledge and assumptions about organizational contexts (Gasser, 1986; Lave and Wenger, 1991; Suchman, 1987). Legitimate system "solutions" to political, situated problems are negotiated, rather than defined and are emergent, rather than explicitly stated (Boland and Tenkasi, 1995).

The five problems of design result in a separation of degree, rather than concept, between the design of a physical artifact and the design of an information system. Current models of design focus on design closure and so delegitimize the essential activities of investigating, negotiating and formulating design problems. We need to focus on "opening up" the design problem, to legitimize the modes inquiry required for effective design of complex, situated information systems. An understanding of this dialectic has significant implications for both the research and practices of design. The situated nature of design requires design models to be constructed through sharing simulated design contexts, rather than through the medium of abstract representational models; this is ill-supported by traditional methods for design. Such constructions cannot be shared intersubjectively, but rather are distributed between collaborating design-group members. Additionally, the contextual constraints upon IS design are considered to have significant implications for design and constitute a critical area of activity which should be managed proactively, particularly where influential organizational decision-makers are involved as stakeholders in a design initiative. These findings have implications for co-operative learning, knowledge management and organizational innovation. If organizational problem-investigation processes are seen as involving distributed knowledge, then the focus of organizational learning and innovation shifts from *sharing intersubjective organizational knowledge* (achieving a "common vision") to *collaborating in constructing distributed organizational knowledge* which is emergent, political and incomplete.

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