NPS-AM-05-032

EXCERPT FROM THE PROCEEDINGS

OF THE

SECOND ANNUAL ACQUISITION RESEARCH SYMPOSIUM

AN EXTENSION AND TEST OF THE COMMUNICATION-FLOW OPTIMIZATION MODEL

Published: 1 May 2005

by

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2nd Annual Acquisition Research Symposium of the Naval Postgraduate School:

Acquisition Research: The Foundation for Innovation

May 18-19, 2005

Prepared for: Naval Postgraduate School, Monterey, California 93943

ACQUISITION RESEARCH PROGRAM
GRADUATE SCHOOL OF BUSINESS & PUBLIC POLICY
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An Extension and Test of the Communication-Flow Optimization Model

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Abstract

This paper reports on a quasi-experimental action research study aimed at extending and testing the communication-flow optimization model, which was developed as a result of a prior grant from the DoD's External Acquisition Research Program. The test is aimed at demonstrating the generality of the model, which is argued to apply to non-defense as well as defense-related organizations. In the study, business process redesign groups in four different US organizations (not defense-related) used two different types of business process representation. The study suggests that, contrary to assumptions likely underlying most of the current business process redesign practice, communication flow-oriented representations of business processes are perceived by those involved in their redesign as significantly more accurate, more useful in the identification of opportunities for process improvement, more useful in the application of process redesign guidelines, more useful in the visualization of process changes, and more useful in the development of generic IT solutions to implement new business processes, than activity flow-oriented representations. The results are consistent with those obtained in similar empirical studies of business process redesign projects involving DoD branches and contractors.

Keywords: Quasi-experimental Action Research, Data Triangulation, Contrast Analysis, Nonparametric Techniques, Process Redesign, Organizational Communication, Electronic Communication

Introduction

Business process redesign (or, simply, process redesign) approaches have become very popular in organizational circles, particularly since the emergence of the business process reengineering movement in the early 1990s (Hammer, 1996; Hunt, 1996; Reijers et al., 2003). The key assumption underlying the development and use of process redesign approaches is that processes can be understood and modified in such a way as to increase both their efficiency and the quality of their outcomes. In such approaches, processes are seen as the basic units of value-added work in organizations.

In spite of being touted as a new and revolutionary idea, it can be argued that process redesign has a long history, dating back to Taylor's (1911) scientific management movement. The scientific management method was concerned primarily with the improvement of manufacturing processes. It provided an approach through which managers could redesign processes in order to minimize times and motions in them, and subsequently encourage workers to follow the new process designs by means of financial incentives. The approach has worked particularly well in processes that involved the handling of heavy materials, and whose executors were largely uneducated and unskilled workers. In that context, the value of Taylor's (1911) scientific management method is undeniable, making it one of the most enduring and successful organizational development methods ever devised.

The time gap between the emergence of the scientific management method and the emergence of the business process reengineering movement is almost 100 years, and many new organizational development approaches have emerged in the interval. Notably, there was the humanist movement, which shifted the focus of organizational development from "processes" to "people," pioneered by Elton Mayo in the early and mid-1900s (Mayo, 1945), and extended by others such as McGregor, Maslow, and Herzberg (Clutterbuck & Crainer, 1990; Herzberg et al., 1959; Maslow, 1954). There was also the total quality management movement, which reverted to a focus on processes but with an emphasis on process quality rather than productivity, pioneered by Deming, Ishikawa, and Juran (Bergner, 1991; Deming, 1986; Ishikawa, 1986; Juran, 1989; Chapman, 1991; Walton, 1989; 1991).

In spite of the time gap mentioned above, many have argued that reengineering is, in fact, a modernized version of the scientific management method (Earl, 1994; Waring, 1991). When one looks at the original reengineering ideas, and the process redesign approaches that followed, it seems that this argument is generally correct. This seems to be true particularly in connection with operational versions of process redesign (Hammer & Stanton, 1995; Hunt, 1996), which, unlike their more strategic counterparts (Caron et al., 1994; Clemons et al., 1995), place singular emphasis on the modeling and redesign of the inner workings of relatively narrow processes spanning one or few areas of an organization.

Perhaps the similarity between today's process redesign practices and those propounded by the scientific management method has extended to one aspect that, this paper argues, has negative implications for the contemporary practice of process redesign. That aspect is the focus of much of today's process redesign approaches on what seems to be a focus on times-and-motions elements associated with workflows, which is reflected in an emphasis on modeling and understanding processes primarily as chronological sequences of interrelated activities (Kock & McQueen, 1996). It is argued in this paper that such focus, although appropriate for materials-handling processes, is problematic when the targets of process redesign efforts are information-intensive processes. It is also argued in this paper that most processes found in organizations today are information-intensive, and that there is a trend toward information-intensive processes significantly outnumbering materials-handling processes in organizations in general—a trend that is likely to grow in the future.

The main goal of this paper is to compare a communication flow-oriented approach to process redesign (which is arguably well aligned with the information-intensive nature of most modern processes) with an activity flow-oriented approach which reflects much of the current practice in connection with business-process redesign. The comparison is guided by a set of hypotheses which builds on a modern theoretical model of business process redesign, namely the communication-flow optimization model (Kock, 2003; Kock & Murphy, 2001). Based on that comparison, this paper argues that there must be a shift in the emphasis of current process redesign efforts, from an emphasis on activity flows to an emphasis on the webs of communication interactions that compose most of today's information-intensive processes.

The above shift is particularly important in the redesign of defense acquisition processes. Among the key reasons for this are the large sums involved in defense acquisition, and the knowledge- and information-intensive nature of those processes. In the case of the US Department of Defense and its contractors, the most widely adopted methodology for process redesign is still an activity flow-oriented methodology called IDEF0 (Ang & Gay, 1993; Dean et al., 1995; Kock & Murphy, 2001).

RESEARCH BACKGROUND

Business process redesign has been a fertile area of research, particularly in the last 10 years. Many important research issues have been addressed, and many relevant research questions have been successfully answered. Harmful misconceptions regarding process redesign have been exposed (Davenport & Stoddard, 1994), and the role of information technology as an enabler of new redesigned processes has been identified and explained (Venkatraman, 1994). Key preconditions of process redesign success have been identified (Bashein & Markus, 1994; Clemons et al., 1995; Teng et al., 1998), and related change management techniques have been studied and validated (Kettinger & Grover, 1995; Stoddard & Jarvenpaa, 1995). New methods and automated tools for process redesign have been proposed (Kock, 1999; Nissen, 1998), and successful approaches for implementation of new process designs have been identified (Grover et al., 1995).

In spite of the progress above, some areas of research in connection with process redesign have received relatively little attention. One such area is that of process representation approaches and their impact on process redesign projects (Katzenstein & Lerch, 2000). This area arguably needs its share of research attention since the way processes are looked at is likely to strongly influence the way they are redesigned. This, in turn, should significantly influence the success of process redesign (Biggs, 2000; Hammer & Champy, 1993; Katzenstein & Lerch, 2000). For example, if a contract-preparation process (arguably an information-intensive process) is represented primarily as a web of communication interactions, it is more likely that problems in connection with communication inefficiencies will be identified (e.g., unnecessary forms that are being filled out and exchanged, which may be contributing to a process bottleneck) than if the process is represented primarily as a chronological sequence of activities. While a focus on activity flows is likely to lead to changes in how activities are conducted, particularly in the sequencing of activities (which is an important consideration in materials handling and assembly line processes), a focus on communication interactions is likely to lead to changes in how information flows within a process (Davenport, 1993; Kock, 1999).

A focus on activity flows makes particularly good sense when the processes being redesigned involve the handling of tangible items (such as raw materials and machine parts) and when tangible items substantially outnumber communication interactions in the processes (Kock, 2003). The problem is that, today, very few processes fit that description. The vast majority of processes, even in manufacturing organizations, have substantially more communication interactions than materials flow interactions (Kock & McQueen, 1996). Also, in certain types of non-manufacturing processes, such as processes whose final outcomes are services or information products, it has been shown that an activity-flow focus leads to overly complex and convoluted process representations, and to several related problems in connection with process redesign (Kock, 1999).

In spite of the above, and perhaps due to the fact that most wealth creation in the last 100 years has relied heavily on manufacturing processes, most existing process redesign approaches focus on activity flows, and largely ignore the webs of communication interactions that make up a large component of modern processes (Archer & Bowker, 1995; Kock & McQueen, 1996; Kock, 2003). For example, the US Department of Defense and its contractors, which, combined, possibly form the largest group of employers in the US, have adopted an activity flow-oriented methodology called IDEF0 as their official methodology for process redesign (Ang & Gay, 1993; Dean et al., 1995; Kock & Murphy, 2001).

One widely used approach to process redesign has been proposed by Harrington (1991; see also Harrington et al., 1998), which not only takes a strong activity-flow orientation but also goes as far as stating that: “As a rule [communication flow diagrams] are of more interest to computer programmers and automated systems analysts than to managers and employees charting business activities” (p. 108). This opinion is obviously at odds with the information-intensive orientation that processes have taken since the late 1970s (Galbraith, 1977), and which has arguably reached high levels since the advent of the Internet in the late 1980s and early 1990s (Kock, 1999). Yet, interestingly, Harrington’s (1991) assertion is well aligned with reengineering pioneers Hammer and Champy’s (1993) view of process redesign, which permeates much of today’s practice in organizational settings.

What about systems analysis and design methods? Are not they information-flow oriented? Yes, they are, but those methods (see, e.g., Davis, 1983; Dennis & Wixom, 2000) have traditionally been designed for process modeling and automation, and have rarely been successfully used as a basis for process redesign efforts (Harrington, 1991; Harrington et al., 1998; Kock & McQueen, 1996). There are some reasons for that. For example, systems analysis and design rules for the generation of business process models using data flow diagrams prevent the representation of certain inefficiencies associated with the flow of information in processes, such as a communication interaction between, say, a forklift operator and an inventory manager (represented as “terminators” in the diagrams) that does not use a data repository (e.g., an inbox) to intermediate the interaction. More generally, no two terminators can be represented as communicating with each other without a data repository intermediating the interaction in data flow diagrams (Dennis & Wixom, 2000). The reason why those rules are followed is that they are consistent with the notion, subscribed to by most systems analysis and design practitioners, that the main goal of systems analysis and design is to understand and subsequently automate business processes with the help of information technologies. Although some progress has been made in recent years, as systems analysis and design methodologists incorporate a process-redesign orientation into their approaches, such process redesign-unfriendly rules exist in both structured systems analysis and design methods, as well as in the more recently devised object-oriented systems analysis and design methods (Booch et al., 1998). In contrast with systems analysis and design, the focus of process redesign has traditionally been to understand and change (sometimes significantly) organizational processes, and then implement the new process designs through the use of information technologies (Davenport, 1993; Davenport, 2000; Hammer, 2000; Hammer & Stanton, 1997).

The picture painted above can be summarized as follows. While activity-flow approaches to business process redesign have been by far the most widely adopted, they do not seem to match the information-intensive nature of modern business processes. There have been attempts to understand that picture from a theoretical perspective, and to propose solutions to the many problems associated with it (Keen, 1997; Kock, 2003; Kock & Murphy, 2001; Ould, 1995). One such attempt led to the development of the communication-flow optimization model (Kock, 2003; Kock & Murphy, 2001). The model, which serves as the theoretical anchor of this paper, is summarized in the next section.

THE COMMUNICATION-FLOW OPTIMIZATION MODEL

The communication-flow optimization model (Kock, 2003; Kock & Murphy, 2001) is concerned with how process redesign practitioners look at organizational processes, and how that perspective affects the efficiency and success of process redesign projects. The model was initially developed based on actual process redesign projects conducted over a period of six years (Kock, 2002), and was later validated through several projects conducted with defense contractors (Kock, 2003). The study described here is one further test of the model, and should be seen as an incremental contribution to the refinement of the model.

Several different lenses can be used to look at and understand organizational processes. Notably, processes can be looked at as sequences of interrelated activities, or as webs of communication interactions (Kock, 1999). One of the core arguments of the communication-flow optimization model is that the webs of communication interactions in a process determine, in a particularly strong way, the quality and productivity of a process. The model argues that much of the variation in the quality and productivity of processes can be explained by the communication-flow structure of those processes, and that a relatively small amount of that variation can be explained through other types of configurations, including activity-flow configurations of the process.

Another key argument made by the communication-flow optimization model, which may seem paradoxical given the above discussion, has been proposed to explain a finding that emerged from the original studies that led to the model. That finding was that, unlike members of traditional systems analysis and design projects (Davis, 1983; Dennis & Wixom, 2000), process redesign project members rarely favored the use of communication-flow representations of processes over activity-flow representations early on in their projects. Moreover, those members consistently perceived communication-flow representations of processes to be more difficult to generate and “less natural” representations of processes than activity-flow representations. The key argument put forth to explain those findings was that activity-flow representations are better aligned with the way in which the human brain has been designed to envision action than communication-flow representations (Kock, 2003). According to the model, the latter representations (communication-flow representations) are subconsciously seen as substantially more abstract, complex, and unnatural than the former.

Nevertheless, since the communication-flow structure of processes is likely to account for a substantial amount of variation in the processes’ quality and productivity, the communication-flow optimization model predicts that process redesign team members will favor communication-flow representations at the redesign stage of their projects. That is, the model predicts that process redesign team members will favor activity-flow representations early on in their projects, when the goal is primarily to analyze the process or processes that are being targeted for redesign. Later, at the redesign stage, though, when process redesign team members try to modify a process or processes with the goal of improving their quality and productivity, the model predicts that those team members will favor communication-flow representations, if any are available. Of course, in many cases those communication-flow representations will not be available, because the initial emphasis would likely have been on activity-flow representations.

Let us assume that a manager of a health insurance underwriting department is asked to come up with a diagrammatic representation of the work performed by the department, which, given the nature of those types of processes, can safely be assumed to be substantially information-intensive. According to the communication-flow optimization model, the manager would most likely draw the different activities conducted by the department, and then connect those activities in a diagram in such a way as to indicate their chronological sequence of execution. While variations could occur, rarely, the model argues, would the manager build the diagram around the communication interactions (e.g., the flow of forms, memos etc.) involved in the underwriting of health insurance. There reason for that, according to the communication-flow optimization model, is that the manager would subconsciously think of activity-flow representations of processes as more natural than communication-flow representations.

In the example above, let us now assume that the manager was asked to propose modifications in the work performed by the health insurance underwriting department, and that he was presented with two different process representations of that work—one depicting the process as a sequence of interrelated activities, and the other as a web of communication interactions. In this instance, the communication-flow optimization model argues that the manager would favor the latter representation in his or her redesign of the process. The reason for that, according to the model, is that most process-related inefficiencies are likely to be caused by underlying communication-flow problems. Moreover, in the implementation of the redesigned process using IT, the model argues that communication-flow representations provide a better visualization tool than activity-flow representations, since there is a clear correspondence between the key elements of communication-flow representations (e.g., data stores) and the key elements of the IT systems used to implement new processes (e.g., databases).

As far as process redesign projects are concerned, the communication-flow optimization model argues that most people will tend to put emphasis on activity flows early on in their process redesign projects, and keep that emphasis throughout their projects, especially if they do not follow a process redesign methodology that somehow “forces” a focus on communication flows. This, in turn, will more often than not lead to sub-optimal process redesign results. That is, the model argues that a somewhat forced focus on communication flows will likely lead to better process redesign results than a natural focus on activity flows.

It is important to note that the communication-flow optimization model is a relatively narrow type of theoretical model, particularly regarding two main aspects. First, the model is concerned with operational-level process redesign projects, which differ substantially from strategic-level projects. In operational-level process redesign projects (see, e.g., Harrington et al., 1998), the main focus is the quality and/or productivity improvement of local processes, which are usually housed in one single department or cut across a few related departments or areas (e.g., warehousing and distribution). Projects involving strategic-level process redesign (see, e.g., Hammer & Champy, 1993), on the other hand, are usually aimed at reengineering broad processes, often processes that cut across an entire company. Second, the model is concerned with process redesign projects in which human beings produce representations of the processes and, based on those representations, come up with new process designs. That is, the model does not address nor dismiss the usefulness of process redesign techniques based on operations research, linear programming, and other traditional assembly-line and factory design techniques that can often be largely automated and that rely to a very little extent on subjective human judgment.

HYPOTHESES

This action research study tested a set of hypotheses derived from the communication-flow optimization model within the context provided by four group-based process redesign projects facilitated in four different organizations. The researcher provided methodological facilitation to the groups. To foster a multiple-perspective view of the target processes, as well as to avoid facilitation-induced bias, the researcher encouraged process-redesign groups to generate both activity-flow as well as communication-flow representations of their target processes, and to consider both types of representations when redesigning the target processes.

The communication-flow optimization model argues that one of the key reasons why individuals prefer activity-flow representations of processes is because those types of representations are better aligned with the way human beings envision “action.” As such, it is reasonable to expect activity-flow representations to be seen, when compared with communication-flow representations, as easier to generate and understand, as well as more accurate and complete representations of processes. These predictions are embodied in hypotheses **H1** to **H4** below.

> ***H1:*** *Process redesign group members will perceive communication-flow representations of business processes as more difficult to generate than activity-flow representations.*
>
> ***H2:*** *Process redesign group members will perceive communication-flow representations of business processes as more difficult to understand than activity-flow representations.*
>
> ***H3****: Process redesign group members will perceive communication-flow representations of business processes as less accurate than activity-flow representations.*
>
> ***H4****: Process redesign group members will perceive communication-flow representations of business processes as less complete than activity-flow representations.*

It is important to test hypotheses **H1** to **H4** to assess the communication-flow optimization model’s claim (Kock & Murphy, 2001) that process redesign group members rarely think of processes in terms of communication interactions at the outset of their process redesign efforts, rather thinking of processes in terms of chronological sequences of interrelated activities, or activity flows, because the latter are better cognitively aligned with the way human beings think of “action.” This claim provides an explanation for what seems to be a generalized preference for activity flow-based process-redesign approaches today (Katzenstein & Lerch, 2000; Kock, 1999) and is, thus, central to the communication-flow optimization model.

Nevertheless, the model also predicts that a communication-flow focus is generally more effective than an activity-flow focus in the context of process redesign projects. In this study, where both communication- and activity-flow representations are used, this would arguably translate into a “change of mind” after the beginning of a process redesign project, reflected in favorable perceptions toward, as well as preferences for, communication-flow representations, as the project moves from process analysis to process redesign. According to the model, this should be particularly noticeable in the redesign phase, where process redesign group members propose changes to a process they already selected and analyzed in some detail. Underlying this predicted preference for communication-flow representations is the heavy role that information technologies are likely to play on process redesign implementations, and the consequent need to address the flow of communication in the processes targeted for redesign (Kock, 1999). This leads us to hypotheses **H5** to **H8** below.

> ***H5****: Process-redesign group members will perceive communication-flow representations of business processes as more useful in the identification of opportunities for improvement than activity-flow representations.*
>
> ***H6****: Process redesign group members will perceive communication-flow representations of business processes as more useful in the application of process redesign guidelines than activity-flow representations.*
>
> ***H7****: Process redesign group members will perceive communication-flow representations of business processes as more useful in the visualization of process changes than activity-flow representations.*
>
> ***H8****: Process redesign group members will perceive communication-flow representations of business processes as more useful in the development of generic information technology solutions than activity-flow representations.*

Hypotheses **H5** to **H8** assume that, when employing communication-flow and activity-flow representations during a process-redesign project, the perception of process redesign group members about each type of representation will reflect a rational intention to achieve the best results possible. This can be seen as a reasonable assumption in connection with the group-based projects investigated here because those were real (as opposed to simulated) projects involving individuals who knew they were responsible for the outcomes of their projects, whether those outcomes were “good” or “bad.”

RESEARCH METHOD

Action research: The roots of organizational action research are in studies of social and work life issues (Fox, 1990; Lewin, 1946; Trist et al., 1970). Organizational action research is often uniquely identified by its dual goal of both improving the organization (or organizations) participating in the research study, and at the same time generating knowledge (Elden & Chisholm, 1993; Lau, 1997). A growing body of literature exists on the use of action research in organizational studies in general, as well as in the more specific context of information systems research (Avison et al., 1999; Baskerville, 1997; 1999; Baskerville & Wood-Harper, 1996; 1998; Myers, 1997; Olesen & Myers, 1999), where research on process redesign has flourished since the early 1990s. Due to space limitations, this literature is not reviewed here. The reader is referred to Lau (1997) for a seminal review of action research within the field of information systems research. Peters and Robinson (1984), as well as Elden and Chisholm (1993), provide more general and discipline-independent reviews of action research. For the purposes of this investigation, it suffices to highlight the fact that, in organizational-action research, the action researcher is expected to apply positive intervention on the organization (Jonsonn, 1991), which is often realized by the researcher providing some form of service to the organization and its members.

By providing a service to a client organization, the action researcher aims to foster a sense of collaboration with his or her subjects, which characterizes most action research projects. This sense of collaboration is believed to promote free information exchange and a general commitment, from the researcher as well as the subjects, toward both research quality and organizational development (Argyris & Schon, 1991; Avison et al., 1999; Fox, 1990). One of the key reasons for the emergence and relative success of action research has been the recognition that the behavior of an organization, group, or individual, can be more deeply understood if the researcher collaborates with the subject or subjects being studied. In the case of an organization, this can be achieved when the researcher facilitates improvement-oriented change in the organization, which was the case in the investigation described in this paper.

QUASI-EXPERIMENTAL ACTION RESEARCH

More often than not, action research is used as an approach to collect and analyze qualitative data. Nevertheless, one of action research's pioneers, namely Kurt Lewin, set a precedent for the use of action research in predominantly quantitative studies, in what later became known as the "classical" variety of action research (Elden & Chisholm, 1993). Lewin often saw action research studies as quasi-experiments, with one key characteristic that set those studies apart from traditional field experiments. That characteristic is that the intervention applied by the researcher is aimed at solving a practical problem, rather than generating an experimental control group. This perspective is adopted here, where action research is employed in a quasi-experimental fashion.

The researcher provided process redesign training and facilitation to the members of four process redesign groups involving consultants, employees and management from four different organizations based in the US. The facilitation was solely methodological (e.g., no specific process redesign suggestions were offered), and also "methodologically neutral" so as not to bias the perceptions of the subjects about the redesign approaches used. The process redesign groups conducted their work independently from each other.

THE GROUPS STUDIED AND THEIR STAGES

The research literature suggests successful process-redesign projects are usually conducted by cross-departmental groups that are typically small in size (usually less than 15 members) and that have a short lifetime (from a few days to typically no more than a few months) during which its members define, analyze, and search for alternatives to improve one or a few organizational processes (Caron et al., 1994; Choi, 1995; Choi & Liker, 1995; Hammer & Stanton, 1995). The process-redesign groups studied here presented these same general characteristics. They lasted approximately 3 months each, had a "core" membership of 3 to 5 members (assigned nearly full-time to the process-redesign projects), and had a "peripheral" membership of 5 to 10 members (which involved external advisors, consultants, and administrative support personnel assigned on a part-time basis to the process-redesign projects). All of the groups were cross-departmental (i.e., they involved members from more than one department) and targeted cross-departmental processes (i.e., processes that involved more than one department in their execution). The term "departments" is used here to refer to organizational units that aggregate employees with expertise in related organizational functions, e.g., marketing department, computer support department, and quality control department.

According to the research and business literature, process-redesign groups usually conduct their activities along three main conceptual stages: *definition*, *analysis*, and *redesign* (Davenport, 1993; Davenport & Short, 1990; Dennis et al., 1999; Hammer & Champy, 1993; Hammer & Stanton, 1997; Harrington, 1991; Harrington et al., 1998; Kock, 2001). In the definition stage, the process-redesign group selects a process for redesign. In the analysis stage, the group studies the process in detail. Finally, in the redesign stage, the group proposes process-design modifications. These stages are followed by the implementation of the modifications. The process-redesign groups studied followed this general structure.

In the analysis stage, each process-redesign group developed both activity-flow and communication-flow representations of their target processes. Activity-flow representations followed the general format proposed by Harrington et al. (1998) for functional timeline flowcharts. While both types of representations contained different types of information, they generally embodied the same “amount” of information (i.e., neither was substantially more “information-rich” than the other). Communication-flow representations were adaptations of data-flow diagrams (Davis, 1983; Dennis & Wixom, 2000), and were generated following the modified format proposed by the researcher (Kock, 1999).

In the redesign stage, each process-redesign group independently proposed several major process changes. Those changes were proposed without interference from the researcher. A list of generic process-redesign guidelines, previously compiled by the researcher (Kock, 1999) based on a survey of the literature on process redesign, were provided to the groups to guide their work. To avoid biasing group-member perceptions in favor of activity- or communication-flow representations, the guidelines were chosen so that: (a) three of the guidelines were more meaningful in the context of activity-flow than communication-flow representations; (b) three of the guidelines were more meaningful in the context of communication-flow than activity-flow representations, and (c) two of the guidelines could be can be applied in both contexts.

Both activity-flow and communication-flow representations of the new processes, with major changes incorporated into them, were then generated. Following this, each process-redesign group developed a “generic” information technology “solution” to implement the new process. These generic information-technology solutions were essentially product-independent computer-based infrastructure and system specifications, and were illustrated through rich pictorial representations (Checkland, 1981; Checkland & Scholes, 1990; Kock, 1999; Kock & Murphy, 2001). The pictorial representations contained icons representing computers, databases and organizational functions responsible for executing individual activities of the new process.

The above stages were followed by the implementation of the recommended process changes, in most cases leading to changes in process-related procedures, reallocation of human and material resources, and use of new information-technology solutions. Implementations took from four months to eight months. Process performance reviews were conducted approximately six months after the implementation of those changes. Those reviews were based primarily on unstructured interviews with managers and employees and aimed at assessing the bottom-line business impact of the process-redesign projects. All four process-redesign groups studied were generally successful in their projects, as the process changes recommended by them met the following success criteria—they were implemented fully or partially and led to positive observable results. These success criteria are consistent with those proposed in the process-redesign literature (Burke & Peppard, 1995; Davenport, 1993; Hammer & Champy, 1993).

DATA COLLECTION AND ANALYSIS

Three main types of research data were collected and compiled in connection with the process-redesign groups: survey-instrument answers (Drew & Hardman, 1985; Sekaran, 1984), participant observation notes (Creswell, 1994; 1998; Sommer & Sommer, 1991), and unstructured interview notes (Patton, 1980; 1987). *Survey-instrument answers* were obtained through a survey administered to the "core" members of each process-redesign group (3 to 5 members) at the end of the work of each process-redesign group. In total, 17 sets of answers were obtained based on a questionnaire. *Participant observation notes* were generated based on direct observation of process-redesign group members as well as other employees who were not directly involved in process-redesign groups yet observed or were affected by the work of the groups. *Unstructured interview notes* were obtained through interviews conducted with the "core" members of each process-redesign group, as well as with other employees who were not directly involved in process-redesign groups, yet interacted with group members or were directly affected by the work of the groups. Over forty unstructured interviews were conducted in total.

The data analysis in connection with the hypotheses was focused on the search for "patterns." The identification of patterns in the survey-instrument answers, which were obtained on a Likert-type scale, was conducted using paired-samples *t* tests (Green et al., 1997; Rosenthal & Rosnow, 1991) comparing the means for answers in connection with communication-flow and activity-flow representations. Patterns in participant observation and unstructured interview notes were identified either based on the observation that they occurred in the majority of the cases (Kock et al., 1997; Miles & Huberman, 1994), or, when the sample size for the unit of analysis under consideration permitted, based on the result of a Chi-square goodness-of-fit test comparing the observed distribution with the expected (or chance) distribution (Siegel & Castellan, 1998).

In order to increase the robustness of the data analysis, the three sources of research data—survey-instrument answers, participant observation notes, and unstructured interview notes—were extensively triangulated (Jick, 1979; Maxwell, 1996; Yin, 1994). As recommended by Maxwell (1996) and Sommer and Sommer (1991), the data set was thoroughly examined for patterns of evidence in support of and against each of the hypotheses, and all the evidence obtained was carefully summarized, compared and double-checked for inconsistencies.

RESULTS

As previously mentioned, unstructured interviews with managers and employees suggested that all of the four process-redesign groups studied were generally successful in their projects. The process changes recommended by them were implemented fully or partially and led to positive observable results, thus meeting general success criteria proposed in the process redesign literature (Burke & Peppard, 1995; Davenport, 1993; Hammer & Champy, 1993).

In this section, hypotheses-relevant results are grouped in three main categories, namely *survey-instrument answers*, *participant observation notes*, and *unstructured interview notes*. Later in the section, the several hypotheses-relevant results, both in support of and against the hypotheses, are summarized in a single table and compared against each other.

SURVEY-INSTRUMENT ANSWERS

Table 1 summarizes the results of a paired-samples *t* test applied on the survey instrument answers. In it, the "core" members of each process-redesign group (3 to 5 members) answered several questions on a Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree). The leftmost column of Table 1 lists 8 constructs associated with business-process representations: *ease of generation* (EASYGEN), *ease of understanding* (EASYUND), *accuracy* (ACCUR), *completeness* (COMPLET), *usefulness in the identification of opportunities for improvement* (OPPORTU), *usefulness in the application of process redesign guidelines* (APLLIC), *usefulness in the visualization of process changes* (VISUAL), and *usefulness in the development of generic IT solutions* (ITSOLUT). The measures for these constructs (one indicator per construct) reflect the constructs identified by Kock (1999) and Kock and Murphy (2001) based on grounded-theory research investigations (Glaser & Strauss, 1967; Strauss & Corbin, 1990; 1998).

	Mean - C	Std. deviation	Mean - A	Std. deviation	*t*	*p* (2-tailed)
EASYGEN	2.82	1.29	3.06	1.30	-0.61	0.55
EASYUND	4.18	1.07	3.82	0.81	0.92	0.37
ACCUR	4.18	0.88	3.12	1.50	2.20	< .05
COMPLET	3.35	1.37	2.59	1.23	2.02	0.06
OPPORTU	4.59	0.51	3.76	1.25	2.38	< .05
APPLIC	4.71	0.47	3.82	1.13	2.76	< .05
VISUAL	4.65	0.49	3.47	1.18	3.64	< .01
ITSOLUT	4.24	1.20	3.06	1.30	3.05	< .01

Table 1. Descriptive Statistics and Paired-samples *t* Test Results

(Quantitative data obtained from structured interview transcripts; range: 1 – 5; Means: C = communication flow; A = activity flow)

Column "Mean – C" in Table 1 shows the means for answers referring to communication-flow representations; column "Mean – A" refers to activity-flow representations. On the right-hand sides of each of these columns are columns showing the standard deviations for each measure. The column "*t*" shows the *t* statistic for each pair of measures. Finally, the column "*p* (2-tailed)" shows the significance level for each *t* statistic based on a 2-tailed test.

The patterns of evidence listed below have been derived from Table 1. They are referred to by "SIA" (survey instrument answers) codes that are later used for data triangulation. The patterns of evidence SIA.$H1_0$, SIA.$H2_0$, SIA.$H3_0$ and SIA.$H4_0$ do not support hypotheses H1, H2, H3 and H4; that is, they provide support for the null hypotheses $H1_0$, $H2_0$, $H3_0$ and $H4_0$, respectively. The patterns of evidence SIA.H5, SIA.H6, SIA.H7 and SIA.H8 provide support for the hypotheses H5, H6, H7 and H8, respectively.

SIA.$H1_0$. On average, group members perceived communication-flow representations as more difficult to generate than activity-flow representations (see EASYGEN row in Table 1). The results of the paired samples *t* test ($t(15)=-.61$, $p=.55$) comparing perceptions for each representation were not statistically significant.

SIA.H2$_0$. On average, group members perceived communication-flow representations as easier to understand than activity-flow representations (see EASYUND row in Table 1). The results of the paired samples *t* test ($t(15)=-.92$, $p=.37$) comparing perceptions for each representation were not statistically significant.

SIA.H3$_0$. On average, group members perceived communication-flow representations as more accurate than activity-flow representations (see ACCUR row in Table 1). The results of the paired samples *t* test ($t(15)=2.2$, $p<.05$) comparing perceptions for each representation were statistically significant.

SIA.H4$_0$. On average, group members perceived communication-flow representations as more complete than activity-flow representations (see COMPLET row in Table 1). The results of the paired samples *t* test ($t(15)=2.02$, $p=.06$) comparing perceptions for each representation were not statistically significant.

SIA.H5. On average, group members perceived communication-flow representations as more useful in the identification of opportunities for improvement than activity-flow representations (see OPPORTU row in Table 1). The results of the paired samples *t* test ($t(15)=2.38$, $p<.05$) comparing perceptions for each representation were statistically significant.

SIA.H6. On average, group members perceived communication-flow representations as more useful in the application of process redesign guidelines than activity-flow representations (see APLLIC row in Table 1). The results of the paired samples *t* test ($t(15)=2.76$, $p<.05$) comparing perceptions for each representation were statistically significant.

SIA.H7. On average, group members perceived communication-flow representations as more useful in the in the visualization of process changes than activity-flow representations (see VISUAL row in Table 1). The results of the paired samples *t* test ($t(15)=3.64$, $p<.01$) comparing perceptions for each representation were statistically significant.

SIA.H8. On average, group members perceived communication-flow representations as more useful in the development of generic information technology solutions than activity-flow representations (see ITSOLUT row in Table 1). The results of the paired samples *t* test ($t(15)=3.05$, $p<.01$) comparing perceptions for each representation were statistically significant.

PARTICIPANT OBSERVATION NOTES

The patterns of evidence listed below have been derived from the participant observation notes generated based on direct observation of process-redesign groups at work. They are referred to by “PON” (participant observation notes) codes that are later used for data triangulation. The patterns of evidence PON.H1, PON.H6 and PON.H8 provide support for the hypotheses H1, H6, and H8, respectively. These were the only patterns of evidence obtained from the analysis of participant observation notes that were relevant for testing the hypotheses—i.e., other patterns of evidence that emerged from the analysis (but that were unrelated to the hypotheses) are not listed below because they are not relevant for the study reported in this paper.

PON.H1. All groups generated activity-flow representations of their targeted processes before they generated communication-flow representations. This is seen as supporting hypothesis H1 based on the assumption that process redesign groups would generate first the process representation that they perceived as the least difficult to generate.

PON.H6. Of all the 37 process-redesign decisions made by the four groups as a whole, 23 process-redesign decisions (62.16%) were entirely based on communication-flow representations of their target processes. The other 14 process-redesign decisions were distributed as follows: 4 (10.81%) were entirely based on activity-flow representations of their target processes, and 10 (27.03%) were based on both types of representations. This is seen as supporting H6 because a Chi-square goodness-of-fit test of the distribution of process redesign decisions ($\chi^2(2, N=37)=15.3$, $p<.001$) suggests a statistically significant preference for the use of communication-flow representations when applying process-redesign guidelines.

PON.H8. All groups developed "generic" information technology "solutions" and respective rich pictorial representations entirely based on communication-flow representations of their target processes. This is seen as supporting hypothesis H8 based on the assumption that process-redesign groups would developed their "generic" information technology "solutions" and rich pictorial representations based on the process representation that they perceived as the most useful for those tasks.

UNSTRUCTURED INTERVIEW NOTES

The patterns of evidence listed below have been derived from the notes generated during unstructured interviews. They are referred to by "UIN" (unstructured interview notes) codes that are later used for data triangulation. The patterns of evidence UIN.$H1_0$, UIN.$H2_0$, UIN.$H3_0$, UIN.$H4_0$ and UIN.$H5_0$ do not support hypotheses H1, H2, H3, H4 and H5; that is, they provide support for the null hypotheses $H1_0$, $H2_0$, $H3_{0,}$ $H4_0$ and $H5_0$ respectively. The patterns of evidence UIN.H6, UIN.H7 and UIN.H8 provide support for the hypotheses H6, H7 and H8, respectively.

UIN.H1$_0$. There was no clear majority perception as to whether communication-flow representations were easier or more difficult to generate than activity-flow representations.

UIN.H2$_0$. There was no clear majority perception as to whether communication-flow representations were easier or more difficult to understand than activity-flow representations.

UIN.H3$_0$. Most group members perceived communication-flow representations as more accurate than activity-flow representations. They generally explained their perception by pointing out that communication-flow representations provided more accurate depictions of the elements that seemed to flow the most in their processes, which they often referred to as "data" or "information." The following quote illustrates this: "*For certain processes, both the workflow and data-flow representations are accurate. However, they are not accurate for all processes. Our project consisted of movement of both work and data […] the work flow diagram depicts the movement of material within different functions […]. They where depicted clearly and in the proper order with correct time frame by the functional time line. Our project also consisted of a variety of data movement[s] like writing the request mutually agreed specification, SOP, and generating the final report […]. The [communication-] flow diagram by far more accurately depicted these data movement[s] than the functional time line.*"

UIN.H4$_0$. There was no clear majority perception as to whether communication-flow representations were more or less complete than activity-flow representations.

UIN.H5. Most group members perceived communication-flow representations as more useful in the identification of opportunities for improvement than activity-flow representations. They generally explained their perception by pointing out that communication-flow representations had not “caged” them into thinking in an “artificially sequential” manner, which was necessary for the redesign of the flow of “data” or “information” within a process. The following quote provides an illustration of this perception: “*The [activity-flow] diagram does not visibly show any wasted effort […] because the [communication-flow diagram] does not show actual tasks[;] it allows one to be more creative than being limited by a particular sequence. In the [communication-flow diagram] sequences aren't greatly represented […] so you do not get in the mindset of following a specific sequence. We can see what is needed, where to get information from, and it's up to us to define the sequence later.*”

UIN.H6. Most group members perceived communication-flow representations as more useful in the application of process redesign guidelines than activity-flow representations. They generally explained their perception by pointing out that communication-flow representations were better visual aids in the identification of problems in connection with the flow of “data” or “information,” which were more frequently observed, and where process-redesign guidelines could be easily applied. This is illustrated by the following quote: “*The workflow representation shows a chronological view. Thus, it is easier to conceptualize the process at first. This will give a quick picture in order to understand the process […] [However,] by utilizing the [communication-] flow [representation], it was [easier] to see the excessive data flowing between the customer and the employees of ACD.*”

UIN.H7. Most group members perceived communication-flow representations as more useful in the in the visualization of process changes than activity-flow representations. They generally explained their perception in the same way as they explained their perception that communication-flow representations were more useful in the application of process-redesign guidelines, as the following quote suggests: “*It is easier to visualize the process changes using the data-flow representations than the workflow representations. With the data flow, you see that different data stores are receiving data from the same functional unit and sending data to the same or different functions. Based upon the data flow representation, it is easy to determine that all of the data stores are not needed.*”

UIN.H8. Most group members perceived communication-flow representations as more useful in the development of generic information technology solutions than activity-flow representations. They generally explained their perception by pointing out that, since the generic information-technology solution automated the flow of communication within a process, the communication-flow representation was particularly suited for its development. The following quote illustrates this: “*[Communication-flow representations give] a much better guideline for development of generic IT solutions than workflow representations. In our case, we used the new [communication-flow representation] and easily converted it to a generic IT solution. We had three main data stores. The first one was used for interaction between customer and ACD employees (in creation of RFS, MAS, SOP). This was easily changed to an asynchronous Web-based communication that was connected to a database management system. The second data store was used by the product technician for performing the test. This was replaced by the Automation system. The last data store stored manual results of lab which was replaced by the Lab Information Management System. This also provided the data needed for the Vice President to finalize the report for the customer and adhere to the ISO 9002 standard.*”

SUMMARY OF EVIDENCE IN SUPPORT AND AGAINST THE HYPOTHESES

Table 2 summarizes evidence in connection with the hypotheses, showing individual patterns of evidence in support of and against the hypotheses. Evidenced against the hypotheses H1, H2… is defined as evidence in support of the respective null hypotheses $H1_{0,}$ $H2_0$…

	Survey instrument answers	Participant observation notes	Unstructured interview notes
H1		PON.H1	
$H1_0$	$SIA.H1_0$		$UIN.H1_0$
H2			
$H2_0$	$SIA.H3_0$		$UIN.H3_0$
H3			
$H3_0$	$SIA.H2_0$		$UIN.H2_0$
H4			
$H4_0$	$SIA.H4_0$		$UIN.H4_0$
H5	SIA.H5		UIN.H5
$H5_0$			
H6	SIA.H6	PON.H6	UIN.H6
$H6_0$			
H7	SIA.H7		UIN.H7
$H7_0$			
H8	SIA.H8	PON.H8	UIN.H8
$H8_0$			

Table 2. Individual Patterns of Evidence in Support of and against the Hypotheses

(Evidence against H1, H2… = Evidence in support of the null hypotheses $H1_0$, $H2_0$…)

The evidence presented in Table 2 is grouped based on its source and indicated by specific acronyms that indicate the source of each piece of evidence—survey instrument answers (SIA), participant observation notes (PON), and unstructured interview notes (UIN). Empty cells indicate that a thorough search revealed the absence of patterns of evidence from a particular source in connection with the respective hypotheses.

DISCUSSION

The patterns of evidence summarized in the previous section provide weak support for hypothesis H1, no support for hypotheses H2, H3 and H4, and general support for hypotheses H5, H6, H7 and H8. This is summarized in Table 3 for convenience. Since the hypotheses were developed based on the communication-flow optimization model, it can be concluded that the patterns of evidence also provide moderate support for the model, reinforcing some elements the model but not others.

Hypothesis	Assessment
H1: Process-redesign group members will perceive communication-flow representations of business processes as more difficult to generate than activity-flow representations.	Weak support
H2: Process-redesign group members will perceive communication-flow representations of business processes as more difficult to understand than activity-flow representations.	Not supported
H3: Process-redesign group members will perceive communication-flow representations of business processes as less accurate than activity-flow representations.	Not supported
H4: Process-redesign group members will perceive communication flow representations of business processes as less complete than activity flow representations.	Not supported
H5: Process-redesign group members will perceive communication-flow representations of business processes as more useful in the identification of opportunities for improvement than activity-flow representations.	Supported
H6: Process-redesign group members will perceive communication-flow representations of business processes as more useful in the application of process redesign guidelines than activity-flow representations.	Supported
H7: Process-redesign group members will perceive communication-flow representations of business processes as more useful in the visualization of process changes than activity-flow representations.	Supported
H8: Process-redesign group members will perceive communication-flow representations of business processes as more useful in the development of generic information technology solutions than activity-flow representations.	Supported

Table 3. Assessment of the Hypotheses

Inconsistent with the model's predictions, process-redesign group members did not seem to perceive communication-flow representations of processes as less accurate, more difficult to understand, and less complete than activity-flow representations. In fact, evidence from both survey-instrument answers (SIA.$H2_0$) and unstructured interview notes (UIN.$H2_0$) suggest that communication-flow representations were perceived as significantly more accurate than activity-flow representations.

Also inconsistently with the model's predictions, process-redesign group members did not seem to perceive communication-flow representations of processes as more difficult to generate than activity-flow representations. Nevertheless, all groups spontaneously generated activity-flow representations of their targeted processes before they generated communication-flow representations (PON.H1).

The above findings put into question the communication-flow optimization model's assertion that activity-flow representations are better aligned with the way humans are cognitively programmed to envision "action" in the physical sense, and its claim that such cognitive alignment is one of the reasons why activity-flow representations and related process-redesign guidelines are so widely used today.

On the other hand, consistent with the communication-flow optimization model's predictions, process-redesign group members perceived communication-flow representations of business processes as more useful than activity-flow representations in the following aspects: identification of opportunities for improvement, application of process-redesign guidelines, visualization of process changes, and development of generic information-technology solutions (SIA.H5, SIA.H6, SIA.H7, SIA.H8, UIN.H5, UIN.H6, UIN.H7, UIN.H8). Also consistent with the communication-flow optimization model's predictions, the distribution of process-redesign decisions suggested a statistically significant preference for the use of communication-flow representations when applying process-redesign guidelines (PON.H6), and all groups developed "generic" information-technology "solutions" and respective rich pictorial representations entirely based on communication-flow representations of their target processes (PON.H8).

The above findings support the communication-flow optimization model's predictions that process redesign group members will prefer communication-flow representations particularly as the project moves from process analysis to process redesign, arguably due to the heavy role that information technologies are likely to play on process-redesign implementations, and the consequent need to address the flow of communication in the processes targeted for redesign.

It is clear that much more research is needed to further test and refine the communication-flow optimization model. Notably, this study suggests that the widespread use of activity-flow representations may be more due to current habits reinforced by consulting companies and management gurus, as argued by Kock and McQueen (1996), than to a cognitive predisposition toward those types of representations, as argued by the communication-flow optimization model. This issue is addressed below in our discussion of implications for future research and practice.

CONCLUSION

This study builds on the communication-flow optimization model and compares two key types of business process representations in the context of actual process-redesign projects. Empirical evidence collected and analyzed through a quasi-experimental action research project suggests that perceived accuracy is approximately 34% higher in communication-flow representations of processes in contrast to activity-flow representations. That empirical evidence also suggests that perceived usefulness in the identification of opportunities for improvement is about 22% higher in communication-flow representations; perceived usefulness in the application of process redesign guidelines is about 23% higher; perceived usefulness in the visualization of process changes is about 34% higher; and perceived usefulness in the development of generic IT solutions is about 38% higher in communication-flow representations in contrast to activity-flow representations.

While the above findings are consistent with the communication-flow optimization model and provide general support for the model, some other findings were not. Contrary to what is predicted based on the model, process-redesign group members did not perceive communication -flow representations as more difficult to generate than activity-flow representations, nor did they perceive communication-flow representations to be less accurate, more difficult to understand, or less complete than activity-flow representations. Interestingly, these findings suggest that communication-flow representations may be even more desirable than predicted by the model, since some of the disadvantages associated with them do not seem to be as significant as initially predicted.

As previously mentioned, the above findings may be seen as putting into question the model's claim that activity-flow representations are better aligned with the way humans are cognitively programmed to envision "action" in the physical sense than communication-flow representations. However, another explanation could be invoked—one that would not require substantial revisions of the key underlying assumptions of the model. That explanation is that even though activity-flow representations are indeed seen as more natural than their activity-oriented counterparts, the information-intensive nature of most processes today (Drucker, 1993; Kock & McQueen, 1996; Kock et al., 1997; Kock & Murphy, 2001) forces individuals into adapting their way of thinking about processes—toward thinking of processes as webs of communication interactions—and thus counterbalances that naturalness effect. This explanation is consistent with the perception by process-redesign group members in this study that communication-flow representations are approximately 8% more difficult to generate than activity-flow representations. Such difference, while statistically insignificant given the sample size, has a noteworthy effect size of about .31. One possible way in which this alternative explanation can be tested is by assessing whether workers involved in less information-intensive processes perceive communication-flow representations to be more difficult to generate than activity-flow representations to a larger extent than workers in more information-intensive processes. That is, in the test of the alternative explanation, information-intensiveness in the processes targeted for redesign would have to be measured and tested for moderating effects on other variables.

This study suggests one key area of future research in connection with the communication-flow optimization model the investigation of the impact of using either communication-flow or activity-flow representations in process redesign projects, but not both (as in this study). This would provide the basis on which researchers could more clearly assess the advantages and disadvantages of one type of representation over and against the other, as this research design would be less likely to be influenced by interaction effects in connection with repeated-measures research designs (Drew & Hardman, 1985; Rosenthal & Rosnow, 1991) such as the one employed in this study. It seems, from the findings of this study, that communication-flow representations may provide a complete and advantageous alternative to activity-flow representations.

Another area of future research relates to the development, refinement and investigation (based on the findings of this study) of methods and techniques that are related to but go beyond the scope of business process redesign. One area in which this line of inquiry may be fruitful is systems analysis and design (Dennis & Wixom, 2000), as there have been research studies in that past (see, e.g., Chuang & Yadav, 2000) suggesting that some new and increasingly popular systems-analysis and design methods and techniques may suffer from the same problems associated with methods and techniques used in process redesign that rely too heavily on activity-flow representations (and too lightly on communication-flow representations).

One example of the above situation is the recent success of object-oriented programming, which has led to the emergence and increasing use of object-oriented methods and techniques for systems analysis and design. In spite of much industry support, the scope of use of object-oriented methods and techniques in systems analysis and design is still not very significant when compared with that of object-oriented methods and techniques in programming. Chuang & Yadav (2000) argue that this is due to object-oriented analysis' excessive activity orientation, which they addressed by developing and validating, with positive conceptual results, a new methodology that applies modified object-oriented methods and techniques to the solution of systems analysis and design problems. This new methodology shifts the emphasis away from activities, as defined in this paper, and onto how communication takes place in processes.

This research has key implications for managers involved in operational-level process-redesign projects. One key implication is that those managers should carefully analyze the focus of their projects, especially when the goal is to obtain quality and productivity improvements through the redesign of individual processes. While a focus on activities and their flow may be advocated by proponents of popular activity flow-based methods such as large consulting companies and recognized management "gurus" such as Hammer (1996) and Harrington et al. (1998), this study suggests that such focus is likely to contribute to less-than-optimal outcomes. Managers should strongly consider moving away from that focus and toward a focus on communication flows and process redesign-related techniques. This is particularly important in broad projects that target primarily service processes, where the flow of materials is minimal, such as the recent organization-wide initiatives by large corporations and government branches to improve acquisition practices (Graves, 2001). In projects of such breadth and magnitude, even single-digit success rate increases can lead to savings in the range of millions of dollars.

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