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How Information Systems Evolve by and for Use

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Abstract

Few studies have examined dynamic interactions between IT change and organizational change during information system evolution (ISE). We propose a dynamic model of ISE which characterizes ISE related change in four dimensions: 1) planned, 2) improvised, 3) organizational, and 4) IT related. The model- generated inductively through theory-building case studies - enables us narrate a more comprehensive explanation of ISE over time- in particular how such evolution is orchestrated by both planned and improvised change, which tacks between technical and organizational modifications. The model thus recognizes dynamic interactions between organizational and IT change by showing how incremental/improvised changes in IT or organizational processes evolve into pervasive and permanent change when organizations institutionalize these improvisations into new permanent IT designs and revised organizational routines. We demonstrate the analytical value of the proposed evolution model by investigating ISE processes in two manufacturing organizations implementing the same inter-organizational system over a period of two years. This multi-site case study research allows us to more systematically characterize significant socio-technical changes triggered by user improvisation. Our model and associated empirical analysis moves explorations of organizational **and** IT change towards a more unified understanding of how both mutually affect the form, function and evolution of the other.

Keywords: Improvisation, Organizational Change, Information System Evolution, Longitudinal Multi-site Case Study.

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Introduction

In the past few studies have examined interactions between IT and organizational change while information systems[1] (IS) evolve. The significance of such evolution where systems "undergo continued progressive change in some of their attributes, which leads to improvement in some sense, and often to the emergence of new properties" (Lehman 2003) has been well recognized in the software research (Lientz and Swanson 1978). System evolution, however, goes beyond software change and embraces also processes of generating and adapting to new requirements by organizations and users. Though earlier research has identified a plethora of management issues related to software change we still understand poorly how such change interacts and is driven by organizational change and what is the role of users in this evolution.

In this paper we seek to fill this knowledge void by probing the following research questions:

1. How do changes in organizational routines and IT interact over time as a part of information system evolution?
2. How do users' improvisations result in permanent changes in organizational routines and IT designs (i.e. modifications and enhancements)?

In addressing these questions, our paper will make two contributions: First, we advance ISE research and associated theories of change by moving beyond software focused change to examine reciprocal and mutually constitutive relationships between user improvisations of information systems and planned organizational and IT changes. Second, we augment improvisation research by considering how improvisations are enabled and constrained by interactions between organizational change and planned IT designs. The remainder of the paper is organized as follows. We will first review research in software evolution, organizational change and IS improvisation and summarize those findings in an integrative dynamic model of ISE. Thereafter we analyze two ISE vignettes drawn from two case studies which illustrate how user improvisations propagate to permanent and pervasive organizational and technical changes. The paper concludes with a discussion of major findings and their implications for future research.

Related research

Software Evolution

The importance of managing and understanding change has been well recognized in software research for at least 30 years. Since first studies of software crisis it has been widely established fact that software maintenance – i.e. changes caused by software enhancements and modifications- accounts for 75% of the total cost of the software during its life-cycle (Lientz and Swanson 1978). Moreover, such evolution, is "inevitable, since changes generated by business policies and operations need to be propagated onto the support software system" (Wan Kadir 2004). Yet, a review of the extant literature shows that antecedents to this constant change remain poorly understood (Lehman 2003). Existing studies mainly articulates internal

[1] The term information system (IS) is defined in this paper as the system that integrates BOTH organizational work routines and information technology to create a socio-technical system (STS).

dependencies within the software that influence software evolution (e.g. source code control and release policies) and define processes to manage it. Environmentally, the extant research has identified a broad set of antecedents for change including new business rules (Wan Kadir 2004), environmental fluctuation, or changing user preferences (Lientz and Swanson 1978). However, being solely software focused it has not explored what generates such changes in antecedents and thus failed to recognize reciprocal and mutually constitutive interactions between software and organizational change. We feel that the IS field is better positioned to marshal evolution studies, which can integrate software and organizational change and analyze their interactions thus offering a more dynamic and comprehensive understanding between organizational change and IT change.

Nature of Organizational Change

We argue that organizational change and software change are inextricably linked and mutually constitutive[2]. This claim draws upon socio-technical theory which conceives any organizational system to combine both social and technical elements while their change is open to triggers from within and without (Trist et al 1963). Socio-technical theory integrates IT and organizational change by viewing socio-technical evolution as a cascading chain of events that traverses through technical and social elements of the socio-technical system in multiple paths and often in unpredictable forms. From this perspective the key in preparing for successful information system evolution is to strike a balance between the social elements- users and organizational processes and IT elements (software functions) (Applebaum 1997) while appealing to socio-technical ideals of effectiveness and flexibility (Majchrak 1997).

In most socio-technical literature change in the system is viewed from the view point of *planned change* (Trist et al 1963): where actors deliberately initiate change in response to new opportunities and technological imperatives (Leavitt and Whisler 1958). Accordingly, organizations orchestrate planned interventions to strike the balance between the social and technical elements. Likewise, dominating approaches to information systems development regard IS related change as planned linear change (Hirschheim/Klein and Lyytinen 1995). In contrast, our view of change in socio-technical systems is predicated on the concepts of both emergent (Mintzberg 1985) and planned organizational change (Hage 1965). Therefore, when we apply emergence as the main analytical lens we view ISE to be caused by improvisations-bricolage- that can accumulate into periods of transformative socio-technical change that leads to the emergence of new system structures and features. This idea is similar to Orlikowski's (1996) situated change concept where transformation is seen as "emerging out of actors' accommodations to and experiments with everyday contingencies, breakdowns, exceptions, opportunities and unintended consequences that they encounter"(Orlikowski 1996)[3].The distinction of planned and emergent change applies to social elements of the socio-technical systems- their organizational routines (Feldman 2000)- as well as to their IT elements. The resulting ISE framework integrates both the *IT and organizational/process components of change* with *planned and improvised types of change,* yielding four dimensions of change as shown in Table 1.

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[2] We are thus only interested in software which supports organizational activities and which thus is embedded and influences the environment in which it operates. In other words we only examine P-class software (Lehman 2003) and ignore e.g. software which calculates sine functions.

[3] Orlikowski's (1996) study fails, however, to explore how user improvisations lead to significant changes in the design of IT. To address this weakness we have added the area of STS change- planned IT change- in our ISE analysis.

	Planned Change	**Improvised Change**
Organizational/Process Change	IS Implementation/Work Routines (Mintzberg 1985; Feldman 2000)	Process Workarounds (Orlikowski 1996; Weick 1998)
IT Change	IT Design and Development (Hirschheim/Klein and Lyytinen 1995)	IT Workarounds and Configured Improvisations (Morch 1995; Orlikowski 1996)

Table 1. Four change dimensions

Theoretical Framework of ISE Change

IS Improvisation Types

Past improvisation research distinguishes two main categories of IT related improvisation. First, improvisations can result from shortcomings or "functional gaps" in the existing IS- normally denoted as workarounds. Second, improvisations can result from a user seizing new opportunities to configure IS capabilities into new functionality- known as configurable IT improvisations. The first type of improvisation is caused by unanticipated "exceptions" during IS use, which will create new requirements on the fly. These exceptions consist of cases that the information system cannot process correctly without human intervention (Strong 1995); or of events for which no applicable rule exists (Saastamoinen 1995). The scope of exceptions covers use problems generated by: 1) erroneous or incomplete information input, 2) requests to deviate from standard procedures, or 3) situations that the system was never designed to handle (Strong 1995). Such exceptions are normally caused by three conditions: 1) operating errors (user error), 2) design errors (design flaw or a missed requirement), and 3) uncontrolled change inherent in dynamic organizations. These cases are resolved through exception handling by identifying the exceptional event and by selecting pertinent action to set the system or the process back to a coherent state (Saastamoinen 1995). Normally, this process involves inventing workarounds, i.e. "intentionally using computing in ways for which it was not designed, or avoiding its use and relying on an alternative means of accomplishing work" (Gasser 1986).

The second improvisation type involves changing the system configuration to meet unanticipated user requirements by using tailorable technologies that allow for modification and adaptation of the application (Mehandjiev 2000). Such configurable improvisations emerge in response to requirements when the existing application is unsuitable for a new task at hand (Morch 1995). Accordingly, two dimensions can be identified to classify improvisations carried out by the user: 1) **Nature of improvisation:** "Configured Improvisations" that take place because exceptions can be met with the designed system tailorability vs. "Workarounds" which are necessary when the current system fails to satisfy user requirements with designed functionality, and 2) **Target of improvisation:** Improvisations consisting of an *adjustment of a process* vs. those that are an *adjustment of the IT*. With those characteristics we can propose the following classification scheme for types of improvisations as shown in table 2.

Improvisation Type	**Process** (Weick 1998)	**IT** (Orlikowski 1996)
Configured (Morch 1995)	*Configured Process Improvisation*	*Configured IT Improvisation*
Workaround (Gasser 1986)	*Process Workaround*	*IT Workaround*

Table 2. Improvisation types

Four improvisation types can thus be defined:

1) Configured Process Improvisation[4] **–** a dynamic modification of an information system process that is facilitated by existing system design functionality. This promotes agile response to changing IT requirements by facilitating the rapid development of new processes.
2) Configured IT Improvisation – a dynamic modification of IT that is facilitated by existing system design functionality. **Examples** include**:** 1) Selecting from options in a system configuration menu of a supply chain system, which allows the user to control the unit of measurement for materials (pounds, ounces, grams, etc), 2) Using filtering options to configure what is displayed on reports (e.g. showing only certain parts or vendors).
3) IT Workaround – an adjustment in the use of an IT, which involves intentionally using it in ways it was not designed. **Examples** include**:** 1) Using a comments field to store the vendor's version of a part number, 2) Downloading data into an Excel spreadsheet to perform calculations and analysis that the primary system could not.
4) Process Workaround – the creation of temporary organizational processes in response to an unmet IT requirement. **Examples** include**:** 1) Planners mailing schedules to suppliers because they were unable to access them due to system problems, 2) Planners calling suppliers to warn them that an order had been added with a due date that was less than the normal lead time (initially planners would just "drop them in", but then suppliers began to complain).

Improvisation Scale

The idea of scales of improvisation was first described by Weick as a continuum, which ranges from "interpretation" (taking minor liberties and adding accents), through "embellishment" (anticipating, rephrasing and regrouping) and "variation" (adding clusters not originally included), which results in full-scale "improvisation" (transforming until there is little resemblance to the original artifact) (1998). Weick describes how any improvisation may fall anywhere on this scale. Those that are "full-spectrum improvisations" have made it through the complete process and are apt to be more pervasive, diffuse faster, and become more permanent. This provides a basis for analyzing how improvisations vary over time thus creating a continuum for analyzing STS changes during ISE. This improvisation continuum was also applied in Orlikowski's (1996) study where improvisations taking place during IS implementation ranged

[4] No improvisations of this type were found in our case studies, so no examples are presented. Therefore, the validity of this improvisation type remains to be seen.

from ad hoc "situated changes" (called "embellishments" by Weick), to long-term changes denoted as "metamorphoses" (Orlikowski 1996) (Weick's "full-spectrum" improvisations).

Improvisation Evolution Stages

By combining the improvisation scale and change type concepts from table 1, we can now formulate an extended model for ISE (see Figure 1) which recognizes the four change stages: 1) ad hoc adjustment, 2) embellishment, 3) modification and 4) metamorphosis. The model narrates how a temporary adjustment in IT use or an organizational process can ultimately evolve into a deep organizational transformation. We next propose the following definitions for each type of change during ISE:

> **1) Ad Hoc Adjustment (IT or Process) –** An initial stage in the evolution process. During this stage, a user creates a solution for a new requirement by producing an IT or process workaround, or a configured improvisation. The improvisation remains localized, and does not result in formal modifications of IT, or organizational routines. Most of these improvisations do not cause further modifications due to the sporadic nature of the unmet need that generated them. **Consider the following example:** A custom query was developed to uncover purchase order lines in the supplier portal that did not match with those in the legacy system. This was used infrequently, as it was developed to meet an unusual requirement.
>
> **2) Process Embellishment –** This stage results from an ad hoc process improvisation, which has been extended to change organizational routines. The magnitude of the organizational impact of an individual embellishment is not highly significant (when compared to a metamorphosis). **Consider the following example:** Material handlers needed to use materials before they were entered into the ERP system. One user improvised a process of leaving a note on the receiving clerk's desk with all pertinent information about material if it was taken before the data was entered. As a result, a formal process was created where a log was designed and filled out for later system entry when materials had been taken prematurely.
>
> **3) IT Modification –** This stage results from an ad hoc IT improvisation being permanently designed into new IT functionality. **Consider the following example:** one key supplier user needed in-transit information for her overseas warehouses, so she improvised a query and spreadsheet system to handle this requirement. Management became aware of the report function and decided to modify the inventory "pull report" so that it could calculate and display in-transit information on all shipments.
>
> **4) Metamorphosis –** This is the "big" step of the ISE process. It consists of a combination of one or more significant modifications of the IT design and one or more process embellishments. The overall impact of this change is deep, as organizational procedures, IT designs, job definitions and use policies are changed. **Consider the following example:** A supply chain strategy was to focus on having vendors manage the inventory control process. This required them to automatically replenish supplies at certain inventory trigger points. A number of inconsistent processes and IT reports were improvised at various plants to accomplish this. The decision was made to leverage the power of the portal system to make it a more efficient and consistent process. As a result, an entirely

new software module and set of formal processes were created and implemented and adopted with associated process changes.

An analysis of the successive stages of ISE improvisations an important step in creating a more comprehensive and dynamic view of ISE which integrates IT change and organizational change into a single model, and which fully recognizes the dynamics caused by user learning and local responses. The model shows how innocent and local user improvisations sometimes grow into path-breaking organizational change. But to do so improvisations must go through an evolutionary process of refinement and institutionalization.

Dynamic ISE Model

We can now propose a dynamic model of Information Systems Evolution (see figure 1). The model offers a baseline for dynamic analysis of ISE by integrating all change dimensions (planned, improvised, IT and organizational) and stages of change (ad hoc adjustment, embellishment, modification and metamorphosis). It illustrates how interactions between organizational and IT changes during at the user context can evolve into significant organizational transformations if and when improvisation scale up to deeper changes during the ISE process.

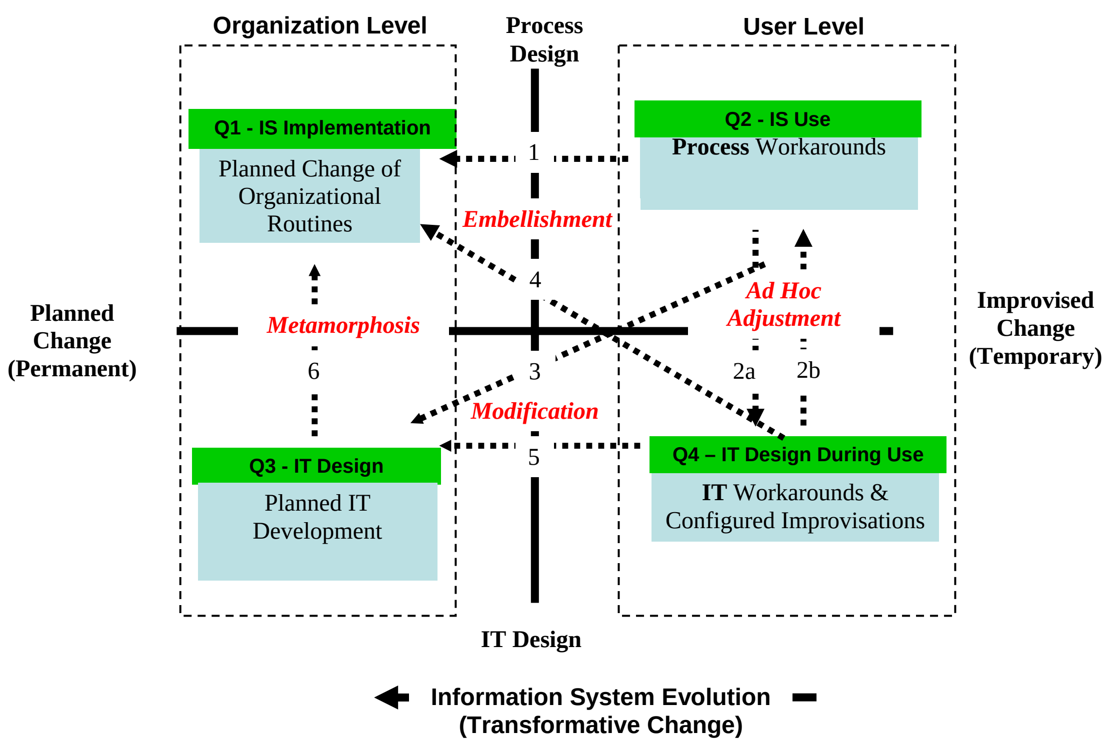

Figure 1. Information systems evolution model

The model identifies four quadrants that characterize our key areas of change. Initially, in Q1- the quadrant of planned organizational processes and structures- rules for organizational routines are created and managed through planning. These are combined with the design of an organization's information technology services in Q3, by designing information systems that meets the requirements set up by organizational structures and processes designed in Q1. The designed IS artifact is instantiated –or rather appropriated- in Q2 during the use process by users who execute organizational routines. As our data and other studies (Orlikowski 1996) show, as IS use transpires over time, users will improvise. This is defined in the model as incremental change either towards IT in Q4 (i.e. IT workarounds and new configured IT artifacts that are improvised during use), or towards new routines in Q2 (i.e. process workarounds) where users adjust their routines to new or unrecognized needs in the organization's environment (Feldman 2004). Influenced by multiple contextual variables and triggers, these improvisations can spur other related improvisations along paths 2a and 2b, or they can evolve into incremental changes in routines in Q1 along path 1. Under certain conditions, as incremental changes along paths 1 and 2 accumulate they can trigger a deeper organizational transformation. During this step major transformations in both planned IT designs (path 5) and routines (path 6) take place simultaneously. Such occasional shifts in organizational structuring represent a significant stage in the ISE process and set the stage for another iteration of the ISE process, which begins again in Q1.

Having formulated the dynamic evolution model we will next apply it in two cases by exploring how two inter-organizational information systems evolved by and for use over a 2-year period. Through this analysis, we seek to answer our research questions concerning ISE and the role of improvisations and their scale during that process. We will use samples of empirical data to examine the interplay between planned (Q1 and Q3) and improvised change (Q2 and Q4) in more detail, and to assess the scope of permanent changes that resulted in two significant ISE processes.

Case Studies

Research Setting

We examined through multi-site longitudinal case study two manufacturing organizations that implemented the same inter-organizational system over a period of two years. In particular we wanted to understand how these systems and their use evolved during this period. The system, "XXX"- an extranet-based package- applies Internet and portal technologies as a medium of exchange and collaboration among multiple actors in the supply chain. The package has been developed by Express, a small software development/consulting firm located in northwest Ohio, which specializes in developing Internet-based e-Collaboration solutions for supply chain.

The XXX package was implemented by Big Brake Company (BBC) a manufacturer of OEM and aftermarket brake assemblies and replacement parts for large commercial trucks for major U.S. "big three" auto manufacturers, and Automotive Interior Manufacturer (AIM), a Japanese-owned company, with only one customer: Honda. AIM manufactures seats and other plastic injection-molded parts for several Honda models. Both companies are middle-market (approximately $500 million in annual revenue), operate as Tier 1 suppliers, have small IT staffs (less then 10 personnel) and saw XXX as an important strategic direction for the future of how their organizations manage inventories and collaborate with their suppliers.

Method

We combined theory building (Glaser and Strauss 1967) and case studies (Yin 1984) with process research (Langley 1999). We chose the case approach because the study involved the examination of a complex social phenomenon and we had a need to "retain holistic and meaningful characteristics of real-life events" and "retain contextual conditions" (Yin 1984). The case study approach also allowed for use of multiple data sources to increase validity of findings through data triangulation (Yin 1984). The study approach we applied closely resembled

Eisenhardt's "Theory Building Through Case Study" approach (1989) in that it involved both theory generating and validating elements. Process research - especially tracking down improvisation event sequences (Langley 1999) were used, because we were theorizing about the ISE processes. Specifically, we looked for explaining how and why events related to ISE unfolded during the course of the study and what types of changes and transformations took place. We observed that the research questions related to ISE required an extended observation timeframe for studied organizations to complete satisfactorily ISE cycles related to figure 1. Therefore, a minimum of a two-year timeframe was selected (4/02-4/04). We believed that the choice of longer time-frame strengthened both the internal and external validity, and the reliability of the study. In this regard our research design significantly extends the time/scope of research designs followed in earlier improvisation studies. Bansler (2003) studied a single implementation over six months, while Orlikowski's study (1996) covered two-years, but it was limited to pre- and post-implementation interviews within one organization and no detailed improvisation event data was collected.

Data Collection and Analysis Approach

We collected data related to system use, improvisation, system changes and related events through formal and informal interviews, passive observation of meetings, training, participant observation where we interacted with the system (such as performing A/P, receiving and purchasing transactions) and use of other ethnographic techniques (taking photographs, taking field notes). We extensively perused the system documentation (such as training materials, memos, articles and e-mails) and physical artifacts (such as issues database, reports and access mechanisms to the XXX system). The data collection followed system users, system managers, system developers and general process managers. Overall, 65 interviews were conducted. Interviews were communicated for interviewees for reliability and validity checks. The intent of using multiple sources of evidence was to triangulate data to increase credibility, corroborate findings and establish a chain of evidence (Yin 1984). Interviews were transcribed and coded for synthesis, cross analysis for both diachronic and synchronic purposes, and for generalization across cases.

The data analysis followed an iterative theory-building process of analysis and verification across data collection rounds using the constant comparative method (Glaser and Strauss 1967). Data collection and analysis results were repeatedly compared with new data to allow for adjustment of the evolving theoretical ISE model and revision of the data collection approach using preliminary, within-case and cross-case generalizations. The analysis of data was divided into two stages. First, during data collection and codification, we looked specifically for improvisation events, which were then categorized by improvisation type (table 2). Second, we mapped these improvisations chronologically to appropriate areas of the ISE model (figure 1) and then followed their movement across change quadrants over time to observe patterns of evolution. We then used the concept of process narrative (Langley 1999) to summarize main explanations for the observed ISE process across different change quadrants.

Findings

After (Langley 1999) we will describe two narratives associated with ISE processes initiated by local improvisations. These two examples show how changes in and for use traversed the entire ISE model from local ad hoc adjustment to organizational metamorphosis. Both process narratives illustrate how key constructs and their relationships can be mobilized to narrate the evolution process. Specifically, these examples were chosen as they met the following criteria: 1) the ISE process reached major change- metamorphosis, 2) they evolved both slowly and quickly, 3) the scope of the organizational change was among the most significant of all this study's ISE processes.

BBC ISE Exemplar: The VMI Process

The management of specialized inventory at BBC underwent a significant transformation during our study period. Through the use of the web portal, user improvisations generated numerous new processes and software modules for the Vendor Managed Inventory (VMI) process. This supply chain arrangement requires suppliers to monitor BBC plant inventory levels of selected materials, and ship automatically when needed. A metamorphosis took place where ad hoc adjustments carried out through non-automated inventory communication processes (e.g. fax, phone and e-mail) and IT workarounds (e.g. new custom legacy system queries and spreadsheets) evolved into major organizational change for BBC and its suppliers. This metamorphosis pushed the XXX system through an ISE process, which resulted in the creation of the VMI system with its associated process supported by new software modules. During our study the system was fully developed and implemented at several BBC supplier sites, with plans for more wide-scale adoption in the near future. The following quote by the Director of Supply Base summarizes the importance of the VMI model at BBC:

> "Our goal all along has been to cut costs, but now we are looking to force suppliers to do their part to make this happen. This means a shift to the VMI model on as many parts as possible, setting good min/max levels and measuring suppliers by the level of success achieved. This is a new way of thinking for us and our supply base, but we are optimistic that we will save a lot of money in the process".
>
> (BBC Interview 2003)

Initiation of ISE – VMI Reporting and Query Process: An IT/Process Workaround. Before the XXX implementation, VMI was being used on a limited basis and with little success. Transmitting demand data via EDI was working for "normal parts". But, VMI suppliers had additional requirements for new information that their current EDI arrangement could not provide (e.g. min/max vs. current inventory levels, cumulative shipments, forecast, etc.). This information was necessary to effectively manage inventory levels. Buyers/Planners from several BBC plants had developed a variety of processes and IT support to meet the requirements of obtaining and communicating detailed information to VMI suppliers, which became part of their organizational routines (Q1 in our model). Some were querying the legacy system, printing reports and faxing them. Others had used personal spreadsheets and e-mailed them. Phone was used extensively to deal with daily exceptions. In many cases suppliers were keying the sent data into their own systems. None of these solutions was particularly effective. According to the system liaison, problems stemmed from inconsistent systems in place across different plants, the legacy system generating demand updates only weekly and not having an efficient means to deliver the information to the suppliers:

> "We have a number of plants that have been attempting VMI for awhile, but it has been a messy process. People were going in different direction, which makes it tough for us to manage from here. Suppliers were getting bad information, and some had to deal with multiple plants with different processes for VMI. Since this is an important strategic process for us, we really needed to find a way to get it under control".
>
> (BBC Interview 2003)

Evolutionary Path. The evolutionary path of improvisations related to VMI will be traced below (figure 2) as it evolved over an 18-month period. The trace shows how local improvisations moved slowly through various phases of the ISE model outlined above. The evolution started as an ad hoc adjustment (Q2→Q4)[5] for the first six months before evolving into the process embellishment stage, which formalized the VMI process for the first time and used XXX functionality to fulfill some of the new requirements (e.g. data downloads) (Q2→Q1). After that the process stabilized. Meanwhile an extensive IT modification was designed to create a new XXX software module and associated processes (Q4→Q3). The new VMI module created the impetus for a large-scale change across the supply chain as new systems and processes were implemented at supplier sites, a new consignment strategy was developed for BBC, and a plan was formulated for the future use of the module as a Kan Ban system ("pull" system where consumption of material automatically triggers a signal to the supplier to send another shipment) using automatically generated e-mail alerts to transmit demand data (Q3→Q1). This provides an example of how an early improvisation generated a large-scale change which caused significant ISE.

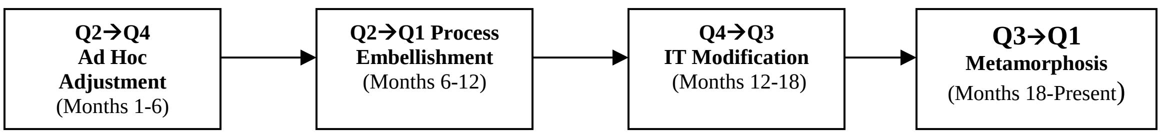

Figure 2. BBC VMI process evolutionary path

Summary. The VMI process exemplifies how a localized improvisation evolves over time into significant socio-technical change. The deployment of VMI had a large impact within BBC and across organizational boundaries. Yet, the whole ISE process was triggered by a set of new requirements that emerged locally, which led to the improvisation with reports and queries by local buyer/planners in different plants. The use of these tools created the initial momentum for change, which pushed these improvisations down the evolutionary path towards more institutionalized and formalized change. The final outcome was the creation of entirely new software and associated mode of inventory operations for BBC in the form of a formalized VMI routine. This metamorphosis has now opened the door to expand the observed benefits of VMI including the possibility of using Kan Ban, and a foundation for new types of consignment with overseas suppliers.

AIM Exemplar of ISE: The Material Tracking and Receiving Process

During the two years preceding the XXX implementation at AIM, one of the most significant problems they faced was the lack of shipment visibility and tracking. This resulted in significant amounts of lost materials. In their prior modus operandi there was no way to track individual shipments from suppliers to AIM inventory. This created significant problems for AIM receiving personnel and material handlers. With no visibility of in-transit material, they had no means to know whether the proper items and quantities had been shipped on time. "Once materials left suppliers, they sort of entered a black hole", was the AIM materials manager's description of the situation. In a lean manufacturing environment followed by AIM- which involves carrying one day of raw material and finished goods inventory- this is highly problematic, as material shortages stop production.

[5] Notation such as this refers to movement between quadrants in the information systems evolution model in figure 1.

The problem was aggravated because transactions related to received materials were not performed accurately and on time. Once materials arrived at the receiving dock, the receiving clerk had to manually key the transaction into AIM's ERP system. This was a lengthy process which took several minutes for each transaction. With hundreds of material shipments coming in each day, this created a constant bottleneck. The problem was compounded by the fact that the receiving clerk also had other responsibilities. As a result, she fell behind as much as three days in entering material receipts. Due to manual entry of a large number of transactions there were significant human errors, which increased processing time. Another problem was the fact that shipment data was sent from suppliers in hundreds of formats, some of which were difficult to decipher. In fact, some suppliers did not send shipment data at all. To make matters worse, material handlers, in order to keep the line moving, often were forced to move shipments out to the production line before the their receipts were recorded. In this process, these transactions were often not entered into the ERP system at all, the documents were lost, and the Accounts Payable department had no record of what materials had been received.

This situation in the receiving process rendered the ERP system information virtually useless as the inventory data was never accurate. As a result, material planners often had no idea what to order. Many times they had to resort to time-consuming physical counts to establish an accurate inventory position. This also caused major problems for A/P, as they were constantly on the phone trying to trace invoiced materials to decide whether they should pay for them. Large volumes of materials were never accounted for, angry vendors were not getting paid, material handlers were becoming increasingly frustrated and the receiving clerk's job was unmanageable. The magnitude of the problem is summed up by an AIM project manager as follows:

> "…but I guess my point is, we knew we were having so many issues internally, with identifying where Associates were not doing their job and getting the data in the system so that accounting could do their job, it was obvious that receiving though was just not doing their job…and accounting couldn't actually pay bills, you know, these are huge issues with inventory accuracy cause you're not receiving inventory in the system. We really needed the ability to really count and project from month to month our profitability and our inventory shrinkage and all kinds of things, so we saw that as being a huge potential benefit".
>
> (AIM Interview 2004)

Initiation of ISE – Material Discrepancy Process: An IT/Process Workaround. When the senior materials director became aware of this crisis, it became his top priority. He was concerned because the list of problems associated with materials affected nearly all departments in the organization. Top management expected a better solution. Most importantly, according to a senior production manager, the situation affected AIM's ability to serve its customers:

> "We run really lean and I only carry one day of raw material and one day of finished goods. If anything goes wrong in the materials process, my line shuts down and I can't serve the customer. The problems with raw material were a huge concern for me because of this".
>
> (AIM Interview 2004)

To begin the resolution process, he began to trace material flows, identifying the problem areas mentioned earlier (supplier shipping, AIM receiving, AIM material handling). He then improvised by creating an ad hoc interim tracking process and associated report called the "Material Discrepancy Log" (Q2), which was quickly formalized (Q2→Q1). This process was designed to identify lost material, so that managers could contact vendors, receiving clerks and material handlers to trace shipments and identify disconnects in the material flow. At the peak of the crisis in the summer of 2003, there were over 100 material discrepancies[6], leaving almost 25% of raw material inventory unaccounted for.

Evolutionary Path. The path of the Material Tracking Process/Receiving Process ISE is traced below (see Figure 3). Due to the severity of the situation, the evolutionary events unfolded rapidly. The improvisation moved from an ad hoc adjustment to a metamorphosis during the first three months of the XXX implementation. It started off as an ad hoc adjustment for one month, while managers experimented with alternative temporary tracking processes (Q2). Next, in order to save time, stages of modification (Q4→Q3) and embellishment (Q2→Q1) proceeded in tandem. This yielded a new XXX software module and associated new processes for supplier shipping and AIM receiving. The receiving module carried with it the necessity for significant change across the supply chain: suppliers were now required to complete shipping transactions through the portal, in order to give instant visibility of their shipments to AIM (Q3→Q1). They were also required to print out and attach a standardized master packing list to all materials. The standardized master packing list was then scanned by a receiving clerk upon delivery, thus cutting transaction time down from minutes to seconds. This allowed prompt and correct movement of materials to the shop floor. This process also gave A/P visibility to all shipments in

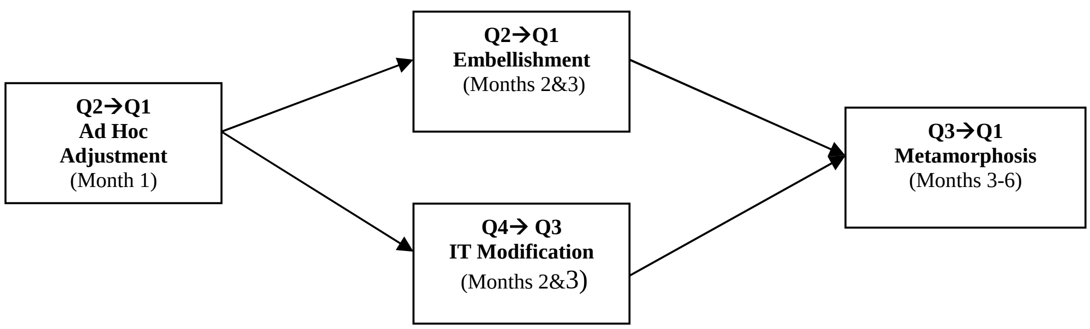

Figure 3. AIM material tracking and receiving process evolutionary path

their ERP system, because shipments and ERP data were synchronized daily through an interface. This visibility assisted with the payment tracking processes. This provides an example of how an improvisation, which is designed to meet an urgent need, can quickly escalate to a large-scale change.

Summary. The metamorphosis of the Material Tracking and Receiving Process shows how an urgent set of requirements trigger improvisations, which can evolve into a metamorphosis in a short time. At AIM the threat that the lost or unaccounted material posed to the company motivated management to improvise an interim solution, and to execute a complete transformation of the supply-side material management process. During the ISE new organizational routines and IT designs were planned, job descriptions and performance measures were modified, and the company's relationship with its suppliers changed. The transformation resulted in a significant evolution of the XXX system, as the existing shipping module had to be modified and an entirely new receiving module had to be created. The case serves as an example of how frequent improvisation accelerates ISE, thus establishing a solid connection between the scale of improvisation and the pace of the ISE process.

[6] Material discrepancies are identified as shipments of material that were not accounted for on the system.

Discussion and Conclusion

This study centered analyzing the interplay between IT and organizational routines, and planned (Q1 and Q3) and improvised change (Q2 and Q4) during the ISE process. We now present these findings in the context of our research questions.

Question 1. How Do Changes in Organizational routines and IT Interact over Time as a Part of Information System Evolution?

We observed that organizational routines and IT, which are formed through a planning process in Q1 and Q3, will evolve and change when instantiated in Q2 during a use process, as users will improvise resulting in modifications of processes in Q2 and later with IT modifications in Q4. This was observed in both cases where user improvisation served as the catalyst for change in IT and organizational routines. These changes in Q2 often resulted in changes in IT designs in Q4, while the new invented processes necessitated matching IT workarounds, or new IT configurations. We also observed a reciprocal effect, where IT improvisations in Q4 accelerated process improvisations in Q2. Although this interplay between organizational routines and IT in the improvised change realm was important for ISE we discovered that at some point improvisations must “cross over” the “Rubicon of formality” to the planned change realm. Only then will they cause information systems to evolve significantly and permanently.

Question 2. How Do Users’ Improvisations Result in Permanent Changes in Organizational Routines and IT Designs (Modifications and Enhancements)?

We found that in response to user improvisation in Q2 localized changes in organizational routines and IT designs generated some time permanent change. In both cases, we saw process improvisations result in permanent changes in organizational routines (Q1), when management saw the value in new processes. More significantly, we observed how improvisations with processes (Q2) and/or IT designs (Q4) escalated to large scale change. We identified multiple instances where a small and localized improvisation resulted in revamping an entire information systems area. This movement back into the planned change arena affected Q3 and Q1 simultaneously when modifications and metamorphoses followed.

The application of this model enabled us to effectively address our research questions and we can now generalize some claims with regards to the possible causes of ISE as follows: First, information systems evolve on a limited basis if planned change or improvised change takes place in isolation. However, when changes cascade dynamically between the planned and improvised changed arenas, the speed, scale and permanence of the ISE is more significant which will result in constant change in software. Second, user learning and improvisation are an important source of software change and evolution. Third, ISE always has both organizational and IT components. Although single evolutionary events can be solely attributed to IT (modifications) or organizational change (embellishments), our analysis shows that the change areas are mutually dependent and constitutive during the overall ISE process. Though embellishments and modifications can individually cause ISE, they mostly occur in tandem and, when combined, they will increase the scale and scope of ISE. Fourth, user improvisations are not insignificant from the view point of socio-technical change- they can end up with large-scale metamorphoses. Such use events can instigate the creation of entirely new IT and organizational functions and/or process. Finally, user improvisations do not result in significant ISE unless they move into the planned change realm, and thus become a permanent part of organizational routine and IT design. This requires that managers recognize the importance of an improvisation for effective and sustained use of the IT resources and continue to sponsor users' change initiatives.

The study expands earlier research on ISE by providing a socio-technical approach to ISE by integrating organizational aspects of ISE with software change. Our study shows: 1) systems evolve by the design and instantiation of organizational routines and software, 2) IT change and software change are inextricable linked and mutually constitutive, 3) systems can evolve through multiple change paths and 4) incremental improvisations by users by and for use drive ISE.

The study also expands improvisation research in significant ways. First, it provides a more comprehensive view of improvisation as it relates to ISE. In this regard we view ISE as a key organizational change process, which integrates and balances change both in organizational routines and software. This extends Weick's (1998) view of improvisation, which solely focused on user generated variation in organizational routine (Q2). We also integrate IT design into improvisation research by showing how use improvisations (Q2) evolve into major changes in organizational routines and software design (Q1 and Q4). This provides additional insight to the evolution analysis, which is absent in Orlikowski's (1996) characterization of IS improvisation. Though she describes a metamorphosis during the evolution, she does not analyze or account for any transitions or interactions that take place in or precede the IT design space when improvisations evolved into software changes (Q3 and Q4). Her focus, in contrast, is solely on transitions from user-level process (Q2) to changes in organizational routine (Q1) which hides the necessary reconfiguration of IT resources for such change to take place.

The study has obvious limitations. First, the results are subject to methodological limitations of a multi-site case study- we do not claim statistical generalizability over a large population of ISE processes. Second, while studying and identifying improvisation events we were forced to rely on users' accounts of their improvisations and their ability to identify them. Faulty recollections, difficult-to-understand terminology, and a tendency towards self-representation could have tainted our data. One way to resolve this in future is to allow researchers adopt a more active role in identifying improvisations through other data collection methods. Extended ethnography could possibly remedy these issues. Second, our findings are based on our interpretation of the collected data, though we shared our findings with the studied organizations and received corrective feedback. During the analysis we were forced to make occasional judgments about the level and scale of improvisations. The reliability of these findings could have been increased through the use of multiple raters and better scales during the analysis process.

We see ample opportunities for future research. A more comprehensive model of organizational change is currently in process. We also need to extend the current model by exploring in detail mechanisms push incremental changes (improvisations in Q2) into punctuated changes that transform socio-technical systems (Q1 / Q3). Second, we need more detailed analysis of antecedent variables and triggers that influence ISE process at different stages. Though the model identifies discrete evolutionary events and shows how the system evolves through them, further research is needed to understand their dynamics over time.

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