FEAR AND DESIRE IN SYSTEMS DESIGN: NEGOTIATING DATABASE USEFULNESS

Tanu Agrawal

M.S. Computer Information Systems, Bentley College, 2002
MBA, XLRI Jamshedpur, 1998
B.A. (Honors) Economics, St. Stephen's College, Delhi University 1996

Submitted to the Sloan School of Management
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY
at the
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
February, 2008

Signature of Author..
Tanu Agrawal
MIT Sloan School of Management
February 8, 2008

Certified by..
Wanda Orlikowski
Eaton Peabody Professor of Communication Sciences & Professor of Information Technologies and Organization Studies
Thesis Co-supervisor

Certified by..
Susan S. Silbey
Professor of Sociology and Anthropology
Thesis Co-supervisor

Accepted by..
Birger Wernerfelt
Chairman, Doctoral Program Committee, Sloan School of Management

Fear and Desire in Systems Design: Negotiating Database Usefulness

by

Tanu Agrawal

Submitted to the Sloan School of Management
on February 8, 2008 in Partial Fulfillment of the
Requirements for the Degree of
Doctor of Philosophy

Abstract

Databases are ubiquitous. They are used for a host of functions including coordination, decision making, and memory archiving. Despite their importance and ubiquity, databases continue to frustrate us, often departing from the goals originally set for them. If databases are such essential ingredients for organizations, what diminishes their usefulness? Besides the nature of the data that is entered into the database, usefulness is also shaped by the fields, features, and functionalities that the database designers originally construct that then shape the kind of data that can be entered into the system.

This dissertation examines the process of database design and the assumptions and concerns adopted by the stakeholders involved in it. I conducted a year long ethnographic study of a university that has been engaged in creating a self-sustaining Environment Health and Safety system to manage research related hazards and to ensure regulatory compliance. The integrated database system was envisioned as a tool that would allow the university to observe and improve compliance practices while keeping records that would be available for self-auditing and government inspection.

My research observations suggest that actors imagine diverse purposes that the database, when complete, should serve. These purposes – entailing the three themes of accountability, efficiency and comparability – appear to guide the design process. As these imagined purposes gain momentum, they translate into both desires and fears for the features of the database. For instance, when efficiency is imagined as a purpose, it creates a desire for features such as drop-down menus that are easy enter information into. The inclusion of such features, however, creates a fear of oversimplification. Through a negotiated process, features such as text boxes are added to address the fears. Yet, every design change negotiated within the database system creates ripple effects with regard to other purposes, generating the need for still further changes. The process of database design becomes highly dynamic and the final database system is a negotiated compromise between multiple trade-offs over time. By juxtaposing these fears and desires, and through the use of causal-flow models, I articulate the process by which databases depart from their original goals.

Thesis Supervisors:

- Wanda Orlikowski, Eaton Peabody Professor of Communication Sciences & Professor of Information Technologies and Organization Studies
- Susan Silbey, Professor of Sociology and Anthropology

This material is based upon work supported by the National Science Foundation under Grants No. 0216815 and 0518118. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the National Science Foundation.

Acknowledgments

I am so glad that this is not an Oscar acceptance speech. I would never be able to keep it down to the length required by those folks at the Academy. My thesis has definitely taken far greater effort – both on my part and on the part of so many people who have helped me the last few years - than it takes to complete a film, or so I would like to believe ☺.

I often jokingly referred to my committee as the 'All Star Women's Committee' because it comprised three wonderful women who have been truly inspirational in so many ways.

I read Wanda Orlikowski's papers even before I started thinking about MIT. Her ideas on Structuration Theory offered such refreshing insights into some of the puzzles that I had encountered in my brief work life. She continued to teach me much more during my stay at MIT. Her doctoral seminar was one of the most influential courses that I have had in my life. I owe Wanda and her teachings for the countless arguments I have had with friends about the objectivity of science. Some day I hope to argue as convincingly as her. Wanda is one of the most meticulous researchers that I have met and I truly owe her for constantly pushing me to make my own work better.

I met Susan Silbey only around my second year at MIT, but she has been so instrumental in my life since then. It is a great testament to Susan as a researcher and as a person that she was always brimming with ideas and encouragement. I can't remember anymore how many times I have run to Susan in the last few years, completely convinced that I could never have one more idea. Susan would always sit me down, helping me organize my research (and often, also my life), ending our conversation with that characteristic question, 'Are you okay?' And, I always did feel better after a panic visit to her office. I am also amazed at how many people would come and tell me that they had heard about my research from Susan Silbey. I am so grateful for everything that Susan has been for me through the course of my stay at MIT.

JoAnne Yates has always been infectious with her enthusiasm for all the research that I have generated. Her support, both within and outside MIT, has been incredible. She would go out of her way to introduce me to people at conferences, to the extent that I was known everywhere as 'Wanda and JoAnne's student.' Without JoAnne's ideas and edits, this thesis would definitely be a lot less readable. Without her communications class, I would still be fidgeting with my presentation remote during presentations. Without JoAnne's immense support, I would not have pulled off my technologically sophisticated, very-virtual, thesis defense. Thank you, JoAnne!

I have always found a home on the fifth floor even though I was officially supposed to be in my own office in E53. Several people contributed to the warm support there. I especially want to mention John Van Maanen and Lotte Bailyn. I learnt much about research methods and so much more from them. John with all his stories about cops and subpoenas made the world of ethnography almost magical. I knew I wanted to create my own legends with my own ethnography. And he read my field notes frequently, offering tons of wisdom. Lotte's pro-seminars were always a highlight of my life as a doctoral student. I can only wish for half of Lotte's energy when I reach her age. She probably read my paper as often as the rest of my committee, always providing her careful comments.

And if the tables and figures in this thesis have some descriptive titles, I owe that to Lotte's research methods class.

The life of a doctoral student is meant to be solitary and isolating. But it was considerably less so for me because of the presence of Alice (Heng) Xu. Alice and I joined the PhD program together in two different groups but found more in common than we had ever imagined. From sharing a cube in the SeeIT office, to going to gym together, to living in Westgate, to going to conferences, to talking and chatting endlessly, Alice has been there through every frustration and every celebration that I have encountered in my research and personal life these last few years. I would call her anytime I wanted to discuss a fresh idea or simply vent. My doctoral journey has definitely been much more manageable and enjoyable with Alice in it.

Several other members of the MIT community consistently provided great guidance. Thanks to Jonathon Cummings for allowing me to collaborate and for showing me how to work on a paper from the trenches; to Stuart Madnick for constantly caring, and for helping me access my research site; to Peter Weill for making me feel welcome at CISR events, and for immensely valuable professional and personal wisdom; to Benjamin Grosof for helping me navigate through the MIT processes; to Tom Malone for showing me how humility goes hand-in-hand with greatness; and to Erik Brynjolfsson for showing me that even seemingly disparate schools of thought often converge. Thanks also to Ayn Cavicchi for introducing me, directly and indirectly, to the cast of characters at Welldon and for providing significant inputs in my research on the Green Labs project. Stephanie Woerner again has been a great support to me – I shall definitely keep coming back for her macaroons. George Westermann at CISR has always had the time to sit with me, offer me ideas, and connect me with the right people.

I really appreciate the presence of several students – past and present – who have shared some or all of my journey. I am especially indebted to Nils Fonstad. From the first time that I met Nils in the winter of 2001 when I was still unsure about Grad School to my defense last week, Nils has always been there. It is rare to meet a human being as warm and supportive as him! I also learnt a lot from other IT doctoral students – thanks to Sinan Aral, Michael Zhang, Jeffrey Hu, Adam Saunders, Lynn Wu, Sumit Bhansali, and Heekyung Kim. My compatriots on the fifth floor have significantly shaped this research and have been wonderful friends and supporters. Ruthanne Huising, John-Paul Ferguson, Jason Jay, Kyoung-hee Yu, Joelle Evans, and Adam Seth Litwin – thank you for everything and for listening to countless renditions of the fear and desire!

MIT, with its 150 years of tradition and rules, can be a daunting place. Sharon Cayley made it seem much less so. I can't imagine how anyone can know as much about the rules and requirements at MIT as Sharon does and her ever willingness to draw on her knowledge to help me is much much appreciated. Thanks also to Tammy Santora and Hillary Ross for easing my administrative battles at Sloan. Anna Piccolo's office provided a warm sanctuary to enjoy calming conversations. I was also very fortunate to share my office suite with Yubettys Baez – her boisterousness always pepped me over the years!

I joined the Sidney Pacific community only in my last semester at MIT. But what a difference it has made to my life. It has provided me with some wonderful times, and even more wonderful friends like Kevin Brokish, Irina Ostrovskaya, Shamim Nemati, Sefa Demirtas and Ozan Candogan. Thank you for being there in the most emotionally demanding phase of my doctoral life.

I am blessed with some wonderful friends outside MIT who have kept me emotionally grounded. Foremost among them is my 'family' in Boston – Anirban Mukhopadhyay, Sujata Visaria, and Medha Pathak. As the junior-most PhD in this family, I received lots of wisdom on work and play, and tremendous emotional support. Malavika Jain, Siddharth Bambawale, Rama Iyer, Chetan Gavankar, Aditya Parmar, Bindu Sunny, Gagan Chawla, Jasleen Deol, Asmita Katdare, Arun Ghosh, Meghana Khanolkar, and Malika Rajan have all provided me with much needed emotional strength and have ensured that I don't become a complete nerd here at MIT. My cousins, Bharat and Shweta, pampered me enough to not miss my family as much.

Finally, I want to acknowledge the best family in this world for providing every bit of strength and support. They are very far in India, but have always stayed the closest to my heart. My sisters, Neeta and Neha, have been my best friends as only sisters can be. Akshad and Anagha, my nephew and niece, will some day understand how much they mean to me. They made me forget my worries and always made me smile regardless of how I had been feeling. Thanks also to my brothers-in-law, Murli and Jignesh, for being a part of the family and for being there.

I dedicate this thesis to my parents – HK and Kalpana – without whom I would have accomplished nothing. Their unconditional and unquestioning support for me fills me with inexpressible gratitude and joy.

Thank you all!

Tanu Agrawal
Cambridge, MA

Table of Contents

I. Introduction

Record systems are ubiquitous. We encounter them in almost every aspect of our lives. We use them as memory aids in which capacity the contents help in coordination and control, and facilitate decision making. In fact our social consciousness is steeped in the contents of the records that surround us – in the state, immigration, and in legal records, at work and at home. At work, electronic record systems or databases record our identity, and track our performance as employees. They retain information about the work that is accomplished or not, which then facilitates appropriate response. Indeed, management of information is often cited as the defining characteristic of modern organizations (DiMaggio 2001; Weber, Gerth, and Mills 1958). Organizations are constantly scanning their internal and external environments for what they hope will be valuable information to inform future decisions. At home, we use our own informal spreadsheets to track household expenses, which then guide us in controlling our finances, and in making decisions about them. We rely on these written and electronic records much more than we would rely on our own memory. Records arguably are potential truth claims. The words in the records have the capacity for tremendous authority and power to trump alternative forms of representation and knowledge.

Despite their potential as truth claims, records are not always as useful as we would like them to be. Record systems serve as memory aids but we may not always trust the knowledge that resides in them. Record systems aid decision making but they also sometimes impede our decision making. The information in record systems is meant to enable better control and coordination and yet control and coordination often fall short of our expectations. In fact, problems with records, such as inaccuracy, incompleteness and complexity, are as ubiquitous as records themselves. Besides limiting the usefulness of records, these problems have implications for policy making, causing both inconveniences and serious challenges.

If record systems are such important aspects of our lives why are they not better designed and maintained? Organizations and individuals embark on the design of record systems and databases with certain goals in mind. But as Feldman and March argue, even though organizations develop such systems for just these goals, most information collected in record systems has little relevance and may not even be considered at the time of a decision. It is thus important to examine why the ubiquitous and potentially valuable record systems prove to be insufficient, with their use often departing from their stated purposes.

Research into record systems often cites political or economic interests as possible causes of unreliable information (Garfinkel 1967; Van Maanen and Pentland 1994). Political interests encourage people to manipulate information when entering it into the record system and economic interests lead to shortcuts and inadequacy of information. However, the information fed into the record system is also shaped by the features and fields that have been designed into it – either by the original developers or through a process of customization. And while users of the system often can, and do, bend the designed system to satisfy their own needs, they are, nevertheless, constrained by what has already been designed into it.

In order to more fully understand the basic capacity of the record systems to retain potentially useful information, one needs to examine how the fields, features and functionality of systems are designed and why particular selections are made. This thesis examines the design process of modern record systems – the database systems. During the design process, the assumptions, beliefs and, concerns adopted by the stakeholders involved interact with the fields and functionalities of the database system to shape one other, thus creating a dynamic system that is a result of a complex design process. The final database system is a negotiated compromise between multiple trade-offs. By juxtaposing these assumptions and beliefs with the features and functionalities, and through the use of causal-flow models, I analyze the process by which databases fail to achieve desired goals and purposes.

In the following sections I first discuss the role of written records in organizations and the larger society. Written records enable coordination and control, but also suffer from numerous shortcomings which I highlight next. I then discuss the prominence of electronic record systems and how they enhance both the capacities and the shortcomings of the traditional record systems. Both the practitioner and scholarly literature have suggested explanations for these shortcomings. I examine these next – from the perspectives of use and design. In the last section of this chapter, I analyze some gaps in the existing literature and how this thesis attempts to address them.

The impact and importance of written records – records as truth claims

> "Truth is a thing of this world: it is produced only by virtue of multiple forms of constraint. And it induces regular effects of power. Each society has its regime of truth, its 'general politics' of truth: that is, the types of discourse which it accepts and makes function as true; the mechanisms and instances which enable one to distinguish true and false statements, the means by which each is sanctioned; the techniques and procedures accorded value in the acquisition of truth; the status of those who are charged with saying what counts as true" (Foucault and Gordon 1980, p.131).

Contrary to the common belief that truth produces power, Foucault argued that it was often power that shaped what was considered to be the truth. Foucault's work highlights the constructed nature of truth and emphasizes the importance of studying truth through its formation. The formation of truth is tantamount to the formation of the "normal." Once the normal is established, it provides a yardstick to channel and assess our behavior, including deviations from the norm. Normalcy is not necessarily defined by law; it is most powerfully internalized in social consciousness through habitual ways of acting and being. Conceptions of normalcy reduce the need for formal punishments, instead relying on self-scrutinizing behavior to check any transgressions from the normal.

Texts promote the dissemination of knowledge which includes conceptions of truth and normal.

> ...truth is characterized by five important traits. 'Truth' is centered on the form of scientific discourse and the institutions which produce it; it is subject to constant economic and political incitement (the demand for truth, as much for economic production as for political power); it is the object, under diverse forms, of immense diffusion and consumption (circulating through apparatuses of education and information whose extent is relatively broad in the social body, not withstanding certain strict limitations); it is produced and transmitted under the control, dominant if not exclusive, of a few great political and economic apparatuses (university, army, writing, media); lastly, it is the issue of a whole political debate and social confrontations ('ideological' struggles) (Foucault 2001, p.42)

Ewick and Silbey (1998) describe the experienced power of textual documents through the story of Millie, an African American working class woman, who had been charged with driving an uninsured vehicle that had been involved in an accident. Millie explained to the judge that she had not been driving the car and it was in fact her nephew who had driven the car without her knowledge. As she explained this to the judge and observed her verbal accounts being transcribed into a written court document, Millie assumed that the written transcription at the court would save her the trouble of any repeated explanations in future court visits and would serve as a source of permanent truth and knowledge about the details of this case. Her faith in the court records was challenged when she discovered in her second court visit that she needed to repeat her account orally to the judge. But Millie's case illustrates the faith that we place in the authority and the truth of the written records.

Unlike non-verbal forms of communication, inscribed accounts "abstract events," allowing them to exist in a "formal, timeless, [and] institutional context" (Ewick and Silbey 1998, p.101) removed from their moment of creation. Permanence, transferability, and facelessness also contribute to the elevated status of written communication over other communication forms (Wheeler 1969). Unlike transient oral communication, written text, especially that which is meant to be stored and recorded, has relative permanence. Once inscribed, words can be invoked and memories refreshed at another time and place. At an organizational as well as an individual level, the permanence of records helps as a memory aid. For example, in clinical practices, recorded information is essential to communicating the history of the patient, and providing a basis for decisions on current patient care (Garfinkel 1967). Moreover, given that records are transferred across time and space, the person who authors a record may be far removed from the consumer of that record, making records sometimes faceless. In fact, once the record is created, it often takes on a life of its own and there is little control on how it will be interpreted. Finally, records can be combined in multiple ways – combined with each other or with other pieces of information -- that give them whole new meanings (Wheeler 1969).

Of course, these characteristics are largely a function of how records are used. For instance, one can choose to delete records, making them less permanent. Similarly transferability can be diminished based on the transmission capacity of the sender and the consumption capacity of the receiver. Even facelessness can vary in different records if authorship is acknowledged or if styles of inscription and interpretation vary. However, as I argue next, the belief that written records are permanent, faceless, and easily transferable makes individuals and organizations maintain them in the hope of greater coordination and control.

Records for Coordination

Records enable coordination across multiple groups of actors as they rely on common information embedded in the records to "transcend the individual" (Yates 1989) and to channel their actions. While 19th century organizations relied primarily on oral reporting mechanisms to communicate and coordinate, written records have supplanted these coordination mechanisms in contemporary organizations.

Berg (1999) argues that forms and records enable coordination in two ways: (1) by mediating and constraining activities, and (2) by helping to recognize the status of changing activities, giving a temporal rhythm to them. In the case of the medical form that he studied, doctors and nurses were able to coordinate their activities based on the layout of the form. They were also constrained in these activities by what they were able to write into the form. The dynamic nature of the form enabled the actors to recognize what stage the activities were at temporally. Thus, the doctors and nurses "not only know *how* their work-tasks interrelate, they also know *where* the process of managing a patient's trajectory is at" (1999, p.387).

Other scholars have shown similar coordinating functions of written records. In Smith's (1984, p.62) analysis of a street confrontation, records again mediate the activities among different sets of actors. She shows how the records associated with the encounter helped coordinate interpretations among a variety of actors such as police, court officials, social workers, and probation officers. These records are abstracted from the location and time of the event, but they allow all these disparate actors to reconstruct the event and participate in it, albeit with their own interpretive schemes.

Written records also enable coordination by serving as boundary objects. Star and Griesemer (1989, p.393) define boundary objects as phenomena that "inhabit several intersecting social worlds and satisfy the information requirements of each of them." Much of the research on boundary objects has studied the use of material artifacts as the "social glue" to facilitate cross-boundary collaboration (Bechky 2003b; Carlile 2002;

Henderson 1991). Records too, often serve this purpose. In Bossen's (2006) analysis of electronic medical systems, patient records provide meaningful information to medical professionals across different boundaries. Records can serve as boundary objects by enlisting diverse individuals and entities, thus facilitating coordination across boundaries.

Records for Control and Accountability

By distinguishing the normal and the deviant, written documents can also be used to control actions. For example, they can be used to distinguish the deserters in the army from those who were in service, to define the aptitude of children in teaching establishments, or to separate healthy from sick in hospitals (Foucault 1979). Foucault explores this subject more substantively in his analysis of sexuality (Foucault 1980) where he argues that norms of sexuality and perversion are laid down by the "scientific disciplines" whose protocols are inscribed in organizational and professional discourse, influencing if not controlling sexual thoughts, behavior, and classifications.

Foucault's influence is found among several researchers who extend his exploration of knowledge and expertise to the formative power of artifacts and written text in defining people and thus controlling them (Hacking 1986; Wilmott 1996). For instance, multiple personality as a clinical phenomenon came into effect in 1875. Hacking argues that before this period, "only one or two possible cases per generation had been recorded,.. but a whole flock of them came after" the official classification (Hacking 1986). The label was not simply diagnostic but inscribed in the person's permanent medical record. Once such classifications were created, and with the aid of textual documents, they could be used to label individuals, create appropriate actions for dealing with them, and channel reactions to them. In this way, written texts and record systems could create new benchmarks for normalcy. For instance, once cost accounting was developed, investors found new ways to assess firms' performance (Miller 2001). In common law systems, once a ruling has been made and inscribed into a written form, it creates a precedent for what law would be in similar future disputes.

Records also facilitate organizational control of individuals by providing a window onto their performance. Information Technology (IT) has been compared to a panopticon[1] in its use for close surveillance (Arnold 2003; Bloomfield and Coombs 1990; Zuboff 1988). For example, in the late 19th century, employees of the railroad were required to provide monthly reports to their superiors documenting their operations (Yates 1989). These documentary records were then used to evaluate employees' performance, and reduce accidents and train collisions.

Records facilitate control for the power holder, but they also highlight accountability: the responsiveness of the subject of control. As an aspect of social control, accountability invites attention to the transactional nature of control. That is, accountability systems, by shaping routine actions and beliefs, by making us answerable for our actions, require performance by both the subject of control and those controlling them. Sinclair (1995) defines accountability as:

> "something a person is or feels (a personal attribute to affect), something a person has been granted (an obligation bestowed or part of a job's contract), something a person exchanges for authority (a property of a relationship), a more abstract and impersonal property of an authority structure, or an artifact of scrutiny."

By their visibility and often accessibility, records invite both authorities and the subjects of control to produce accounts that portray their performances in advantageous ways. From the perspective of the authorities, records participate in systems of accountability in two ways: (1) they allow lines of responsibility to be verified; (2) they

---

1 The Panopticon was a physical architecture developed by Jeremy Bentham in the 18th century to afford constant surveillance of others. Michel Foucault (1979) cites the surveillance power of the Panopticon as a symbol of our disciplinary society.

create new or reinforce existing lines of responsibility. In the first situation, the records are used by the subject of control to provide accounts of his/her actions in an existing relationship of control. By making actions visible beyond the space and time of performance, records can also be used by superiors as a sign of the subordinates' performance. In the second situation, the accounts in the records may create new relationships of control, as well as reinforce existing ones as seen in the examples of Hacking and Foucault about sexual perversion and multiple personality disorder. The contents of the records created a new relationship between the psychiatrist and the patient, who could now be labeled as suffering from a named disorder.

The increased visibility of lines of responsibility facilitated through records leads to potential control by others since a person authorized to view the record can access an individual's accounts of his/her actions. The transactional nature of accountability is illustrated in the performance on the part of the subjects of control, who alter their behavior in anticipation or fear of the record. We check our own driving speeds for the fear that our driving records would be affected, if we were caught speeding. In this way, the potential contents of legal records shape and constrain our behavior, despite the subjectivity involved in the creation of such records (Trace 2002; Van Maanen and Pentland 1994). The increased visibility provided by records also allows individuals to create accounts of their own lines of responsibility thereby manifesting self to others (Roberts 1991). The individuals can choose to display aspects of themselves that they want others to see. In the cost accounting example, firms now choose to present their accounts in manners that would portray their performance favorably to the investors.

Thus, using records as truth claims facilitates coordination and control, and ultimately decision making. Records embed norms used to monitor performance; they serve to justify evaluative actions or to prevent them. Yet records are not always as we would like them to be, often falling short of their goals and our expectations.

Problems with record systems

Despite the ubiquity of record systems, we often view records with suspicion. Both the scholarly literature and the popular media present instances of 'bad' records (Garfinkel 1967; Heath and Luff 1996). Records serve as truth claims but the 'truth' in them can be far from factual – it may be incomplete; or inconvenient to process; or it may simply be inaccurate. To the extent that decisions rest on these records, they are likely to fall short of expectations.

Incomplete

Record systems, especially modern ones, hold abundant information. But their reliability is somewhat diminished because they often fail to keep some relevant information. This may be because some kinds of information are easier to maintain than others. Arrest records illustrate this problem. Often arrest records for individuals continue to show up in the public domain even though the charges may have been dismissed. This is because it is easy to record the initiation of legal proceedings but difficult and expensive to track their conclusion and verdict (Lemert 1969).

Record systems may also be incomplete because it is difficult to maintain increasingly large databases, which may hold rapidly changing information. With more than a million personnel in the US Army,[2] the database to track these people is huge, requiring constant updates on recruitment, service deployment, injuries, and casualties.

[2] Using the 2007 figures, Wikipedia lists the approximate combined component strength of the US Army as 1,055,734

Yet, as reported in several media sources, a few days after Christmas in December 2006, the US army sent letters to about 5000 former Army officers who had left the service, urging them to return to duty. Included among these letters were letters to about 75 officers killed in action and about 200 wounded in action (Chicago Sun-Times, 2007). The US Army's database had not been updated to record all the war related casualties.

Inconvenient

Even if efforts are made to maintain complete information in the database systems, the database may be designed to create processes contrary to the accustomed way of doing things. For instance, doctors are accustomed to prescribe drugs that are most appropriate for a patient. But Litwin (2008) describes a database that made it easier for the doctors to prescribe some drugs rather than others in order to keep insurance costs down. So, they created structured text fields—fields that would complete as the doctor began typing in a drug's name. But, what if the doctor judged that one of the non-formulary drugs was what the patient really needed? In the initial version of the software, the doctors were not allowed to override the options offered by the system. In a subsequent version, the doctors were allowed to override the system choices but only after they provided a specific reason for each override.

Such design constraints, introduced to control decisions and work processes, cause inconveniences, in this case to both the doctors and the patients, and provoke users to look for workarounds that then create unanticipated challenges. For instance, a newly designed electronic medical record system in Britain limited both the type and the amount of patient information that the doctors could enter into the record, constraining the physicians so much that they continued the use of paper records in addition to the computerized records. But this dual system arguably compromised the information more than the traditional paper based system alone because the alternative system produced a lot more variability in the way paper records were produced – much more so than with the exclusive use of paper-based records for which everyone implicitly used well-known standards of documentation and interpretation (Heath and Luff 1996).

Inaccurate

Record systems create further challenges when their contents are not just incomplete, or inconvenient to use, but also erroneous. For example, in the US, record systems maintain credit records for most individuals. These records influence an individual's ability to get loans or mortgages, and even to lease apartments. Despite the importance of these credit ratings, scores are often erroneous. For instance, an individual's refusal to pay the bill for a defective product is sometimes entered as non-payment in her credit report, adversely affecting the credit score (Rule, Caplovitz, and Barker 1969).

Inaccuracy is also created when phenomena are difficult to capture through the record system. This problem is seen especially in the case of metrics used in record systems that are meant to facilitate decision making. Not everything can be easily represented through a quantified metric and thus shortcuts are adopted to force-fit information in the system. For example, when evaluating the cost of constructing a dam, economists wanted to estimate the value of water sports on the river, since the new dam would displace those leisure and recreation activities for thousands every warm weekend. Yet, the dam costs eventually did not incorporate the value of shutting down the recreational uses because it was difficult to impute a numeric value to this activity. All other costs and benefits were being computed numerically (Espeland and Stevens 1998).

Record systems, through their limitations, thus, create several consequences not intended in the original design. The decision to maintain arrest records was undertaken to retain memory about criminals and convicts that would help in the prevention and prosecution of crime. The cost-benefit analysis on the dam construction was done to make an informed decision about initiating the dam construction. The army records are maintained to track soldiers' enrollment, performance, and release from service. Yet, as these examples illustrate, our databases do not always satisfy the purposes for which they were intended– certainly not all the purposes. The medical records may help keep the insurance costs down, but they also impede doctors' convenience in writing medical prescriptions.

The impact of these limitations escalates with the growth of record systems. Records, when inaccurate, create independent problems and inconveniences. Doctors do not like to be forced to go through the additional step of describing the reasons for wanting to override the formulary drug. Inaccurate credit reports can prevent people from making essential purchases. Record designs can also have far more serious implications. Imagine a doctor who decides not to prescribe a more appropriate drug to a patient simply because of the additional work involved in prescribing the alternative! Omitted information, as in the case of legal verdicts, may also have troubling implications. An individual with an arrest record that fails to show subsequent dismissal of charges could have lifelong difficulties in securing jobs or credit.

Records and their contents may also lead to misguided policy decisions. In the case of dam construction described earlier, the economic analysis left out the value of the displaced recreational activity. When the contents of analysis are far too disparate as in this case, they are often simply left out of the metrics regardless of how important they may be for the policy decisions.

Finally, careless record designs can reward a particular behavior or outcome when the organization intended to reward another (Kerr 1975). For example, Ridgeway (1956) described a factory in which the employees' performance records tracked only the number of widgets produced. Consequently, employees neglected most machine repairs, only performing ones that were least time consuming, and not those that were most urgent. This led to frequent machine breakdowns that eventually led to a fall in factory productivity. The records, in this case, impeded factory performance instead of helping to enhance it.

The consequences of record systems – both their virtues and limitations – are amplified in electronic record systems with their greater information capacity, and ability to influence the lives of many more actors.

Modern record systems – The electronic database and enterprise-wide database systems

With the growth of computers, electronic databases have supplemented, and often replaced, traditional written record systems. The electronic record systems potentially enhance both the capacity and the shortcomings of traditional record systems. With the increased ability to store vast amounts of information, the electronic record systems are able to store more information without significant space constraints, at least up to a limit. In that sense, the information could possibly be more permanent than in the written records. For instance, the number of files maintained on consumers in credit systems has grown significantly since the adoption of computerized data management. These vast files provide an enhanced capacity to monitor the activities of customers in the credit system (Rule 1973). Information is also more easily transferable given all the data transmission possibilities. Rule argues that the data in the credit files is not always collected and maintained in an obvious manner. Often data collection and monitoring techniques, especially in the more sophisticated systems, are subtle. Moreover, data is collected not through a single source. Instead, there are several points of contact between the client and the system, and each point allows the collection of yet more information. These aspects of the database are likely to enhance the facelessness of the records. Finally, the electronic systems are more easily able to sort, analyze, and aggregate vast amounts of information. This capacity is especially seen in the case of enterprise wide database systems (Enterprise Systems or ES) that integrate information from local systems and processes into standardized forms.

Since the early 1990s, ES packages have become the norm in large organizations. There is a widespread belief that the ES will enable integrated and seamless processes that will speed up the decision making in the organizations. A standardized data format will allow greater integration, which should lower data maintenance costs and increase capabilities for sorting, analysis and aggregation. Greater integration is also expected to produce increased collaboration between departments and enable a centralized management over more streamlined operations. The idea of Enterprise System adoption is made yet more seductive by the apparent success of reported stories (Ross and Vitale 2000). For instance, the IBM Storage Systems division is reputed to have reduced the time required to reprice all of its products from 5 days to 5 minutes, the time to ship a replacement part from 22 days to 3 days, and the time to complete a credit check from 20 minutes to 3 seconds (Davenport 1998). In this way, electronic database systems, especially Enterprise Systems ,are credited with bringing far greater coordination, control, and aggregation through their increased capacity and enhanced standardization.

This increased capacity also brings increased risks of inaccuracy, incompleteness and inconvenience. Increased standardization of data makes innovative data analysis difficult and prevents the accommodation of anomalies. The tight integration of systems makes changes difficult and leads to several inconveniences as compared to previously adopted practices. For instance, in SAP, one of the leading ES software systems, users have to navigate through many more screens to accomplish some processes than they needed do with the old, less integrated systems (Gosain 2004). Such inconveniences can take a serious turn as seen in the case of FoxMeyer Drugs, a company that went bankrupt after an attempt to implement an ES package that could not accommodate several of their routines, including an established practice of shipping orders in multiple shipments (Soh and Sia 2004). With a single source of data entry in an ES, and multiple consumption points, any data inaccuracies also have far reaching risks and repercussions. Moreover, the standardization required in the ES may cause unsatisfied local demands. In fact, incomplete data in ES often leads to the creation of several 'shadow systems' that bridge the gap between local requirements and the ES capabilities. Wagner and Newell (2004) observed such shadow systems at a university that was attempting to implement an ES. Since the faculty researchers wanted their own reporting formats that the ES could not support, they continued to maintain their Excel systems, only using the data from the ES to populate their Excel spreadsheets.

Costly standardization may exacerbate some of the shortcomings of traditional record systems. Yet, most of these shortcomings, although greater in scale, are not that different from those seen in traditional record systems. The arguments that I present next from the literature about the sources of these shortcomings are typically applicable to both traditional and modern record systems.

Sources of database shortcomings

Explanations for problems with record keeping center around two dimensions: (a) data entry and use once the database is in the hands of the users, and (b) inadequate process of database design. I discuss these arguments starting with those around the database use.

Shortcomings due to database use

The research around database use suggests that people create shortcuts during data entry or manipulate data for self serving interests or are unable to find the information in the database useful because the representations in the database inevitably depart from the reality of the users.

Economic interests during database use

Record keeping, like most other tasks, can be viewed through an economic lens of cost-benefit analysis. What is the cost of maintaining an extra piece of information and what benefit may accrue from it? The costs of record maintenance are well studied in medical record keeping.

Medical professionals maintain records in ways that attempt to satisfy the "contractual reading" (Garfinkel 1967) – they can validate that the patients were treated in a responsible manner. This may, however, exclude other information such as the patients' history, medication, diagnoses, etc. In the traditional medical record system that Bossen (2006) studied, health professionals could simply describe a disease and a treatment in the text box. But the new electronic record system required extra work involved in providing details in different fields; first the 'health state,' then the 'focused information' and then the 'health activity,' finally linking them all together. This made many time-pressed health professionals less keen on completing the records. In fact as the medical professionals are forced to use these time-consuming record devices, they find other ways to economize on the information that would be recorded. In a study by Beckman et al. (1984), physicians quickly interrupted their patients as they stated their opening concerns, and took control of the visit by asking questions specific to the close-ended format of their forms.

Concerns of time and effort, thus, could lead producers to generate incomplete data that can mitigate the usefulness of databases or record systems. Such concerns of economy – both on the producers' and the consumers' side – compromise the usefulness of record systems in another manner. Record systems would be more useful if producers of data could also provide the information around the generation of that data. This would then enable the data consumer to trust the data more, and interpret it in more appropriate ways. However, producers of data typically do not want to expend the effort in generating this extra information. Similarly, the consumers of data do not want to scan through this additional information either. Desrosieres (2001) calls this the 'metadata paradox":

> From a normative standpoint, users must be given a maximum of detailed information on the data-production process. It is also true that, from a descriptive standpoint (i.e., without passing judgment), many users do not welcome an abundance of metadata: "ideal" information is that which seems self-sufficient, without footnotes to interfere with the message. (Desrosieres 2001, p.346)

Thus, data producers economize on time and effort, creating incomplete data. Even if they are willing to put in the extra effort, their belief that users are pressed for time leads them to generate minimalist data.

Political interests during database use

While economics provides a 'rational' explanation for compromised data, data shortcomings also reflect political dimensions. Both producers and consumers of information want to engage with data in ways that serve their interests. They may manipulate their data production and consumption, or their actions may be less deliberate. Nevertheless, these actions, deliberate or not, shape the data that resides in the database.

Several scholars have highlighted the malleable nature of the records, shaped by the record producers' interests (Bossen 2006; Cochran, Gordon, and Krause 1980; McKemmish and Upward 1993; Trace 2002; Van Maanen and Pentland 1994). Cochran et al. (1980) argue that contrary to the perception that records are mere representations of facts, "a record keeper's plans, goals, intentions and assumptions precede and therefore shape the record" (p.6). Van Maanen and Penland present similar arguments in their work on cops and auditors:

> "Organizational records, like any product of a social process, are fundamentally self-conscious and self-interested. What is recorded is never simply 'what happened' because, first, no event can be fully or exhaustively described and, second, all records, as institutionalized forms, represent the collective wisdom of those who are trained to keep them. Records are not factual, neutral, technical documents alone, although while serving legitimate ends they must appear this way, and while serving illegitimate ones even more so. They are designed – implicitly or explicitly – to produce an effect in some kind of audience, which itself actively uses records to interpret events. This is not to suggest conscious deceit or cynicism on the part of either record keepers or users (although this is certainly possible). Rather it is simply to acknowledge and open up for analysis the conditions under which organizational records are produced and used" (Van Maanen and Pentland 1994, p.53).

The record keeper may have very specific goals in mind when creating the record, or he/she may be trying to maintain the status of existing interpersonal relationships. Cochran et al. (1980) provide the example of federal and state legislatures who "stop" their clocks on the last day of the legislative session in order to complete the items on their agenda. The time recorded, in this case, is intentionally manipulated to serve the purpose of the legislative assembly. Similarly, auditors create their working papers of the audit purposefully to prevent any legal liability should their audit numbers be questioned. Van Maanen and Pentland (1994) discuss how the auditors systematically purge these working papers in order to present a clear account of their audit process.

Record creation may be less purposeful, where the contents of the records are shaped by the record creator's desire to maintain a persona or the status of existing relationships.

In his study on parole officers, McCleary (1977) argues that parole officers' choice to report a parole violation is often dependent on the relationship between the officers and the parolees. The parole records reflect on the parole officer – whether he is strict or humane. In this way, records often create a representation of the record creator. Although every entry made by the parole officer is not intentionally deliberated, there are underlying interests that shape the contents of the parole record. Similar instances are seen in institutional records. In his study of an educational program, Bogdan (1976) found that the government directive to increase the number of handicapped children in the program led to the schools classifying previous "normal" children as handicapped.

Intentional or not, record creators often shape records in self-serving ways.

Lost in translation during database use

Economic or political interests may cause deliberate or unconscious compromises to the data and limit their usefulness. But data could also prove to be unsatisfactory simply because the reality of the world is far too complex for the database to capture. Once people start using the database system they may realize that the representations in the database system do not quite capture the realities of their day-to-day worlds.

> "Representations of work are heuristic devices in design process, and there is a pertinent danger when such representations pass through different groups and are used for different purposes" (Bossen 2006, p.70).

The representations in the database may differ from the reality because the reality is difficult to capture, or has been misunderstood, or has changed over time, or it may differ for different groups, and a single database cannot capture it all. Suchman (1995) describes her observations of document coding in litigation work, which illustrates how reality could be misrepresented. The form for such coding appeared simplistic, and made the task of coding seem unskilled. But actual observations of the coding task showed that it required considerable skill to accomplish.

Reality may be misunderstood because of the lag that exists between the requirements imagined by the producers and the requirements perceived by the consumers of the database system. There is also a time lag – databases may be designed with a certain context in mind that could now be outdated with changing institutional and environmental contexts. Information is lost in translation when used in a context that is different from the one originally envisaged by the designer. This was observed by Markus (2001) in her study of knowledge repositories. Knowledge repositories are created by those having expertise, to be used by themselves, or people similar to the experts, or people dissimilar to the experts. In all these cases, especially in the last, the knowledge lost much of its meaning because it was distanced from those producing it. The experts generating the knowledge could not apprehend the uses to which the knowledge would be put by the diverse set of users and so did not know what to include in these repositories. Markus's observations illustrate that reality is difficult to capture, and even if such a possibility exists, risks of lowered usefulness only increase with the increased diversity of potential users. This is also evident in enterprise system implementations as illustrated by Wagner and Newell's (2004) observations of an ES implementation at a university. The accounting 'best' practices that were embedded in the package could not accommodate the diverse practices that faculty at this university used. As a result, the faculty resisted the implementation of the ES and eventually found ways to work around the constraining standards imposed by the system.

Constraints built into the artifact during design

Thus far, the arguments largely focus on data production and usage that occurs once the database system is already in existence. They present several reasons for why data may be compromised through data entry or data consumption. While data entry and consumption may differ from how they were intended by the designers of the database, arguably the features and functionalities of the database system, as designed, influence the entry and consumption. Therefore, it is also important to examine the process of database design and how this process may contribute to the less-than-useful database system. As an artifact, the produced database system has important implications for how it may be used, and thus how it constrains and enables people's actions.

The constraining and enabling capacity of artifacts has been discussed by several scholars (Akrich 1992; Grint and Woolgar 1997; Van Oost 2003). For instance, Van Oost describes how designers use a gender script in their design of the shaver, which then ends up further reinforcing the gender script. The razor produced for women had certain design characteristics, such as hidden screws, intended to represent female users as 'technophobic.' This inhibited the women users from seeing the technology behind the shaver, further reinforcing the belief that it was womanly to shun technology. Van Oost acknowledges that women could reject this gender script and create their own, but the design of the shaver made such challenges difficult. In Akrich's discussion of electrification in the Ivory Coast, she illustrates how the electric meter defined the boundaries between the consumer and producer of electricity. The designers created controls in the meter so that it became invalid as soon as either the producer stopped supplying electricity or the consumer stopped paying for it. Even mundane artifacts such as a hydraulic door hinge shape whether we may have the door open or closed (Latour 1992). In the days before the hinge, one had to rely on the will of the users to close the door once they had entered through it. The hinge, however, diminishes this human discretion of keeping the door open or closed.

Similar to material artifacts such as the shaver or hinge, informational artifacts too have the ability to shape actions and behavior by defining the normal and deviant, by engaging in work processes, and by making some things more visible than the others. For instance, accounting standards create a vocabulary of costs and costliness and what Miller calls the "calculable self." "Statistical work not only reflects reality but, in a certain sense, establishes it by providing the players with a language to put reality on stage and act upon it" (Desrosieres 2001, p.352). Accounting and statistical practices allow individuals to manage not only organizations, but also themselves, so that behaviors can be combined into aggregates, compared against standards, and then accepted or rejected. In this way, accounting conventions contribute to the Foucauldian world of expert systems, where individuals channel their actions, or are checked by others, based on the legitimate criteria set by these conventions. These conventions tell the individual what rational behavior is in a world full of choices.

Berg and Bowker (1997) illustrate the role of informational artifacts in a network of organizational work processes. They discuss the role of medical records in mediating the body, in reproducing hierarchies, and in organizing the temporal flow of work, and the work practices of the nursing professions. Records do not determine these, but they are not mere representations of them either. They are one of the artifacts in a network of several others such as medical instruments, professions, etc. that together co-create one another. Medical records provide an infrastructural element which different organizing bodies use in their own locales to create interpretations of and for their work.

Informational artifacts also have the ability to render visibility and legitimacy to some actions, while making others invisible and illegitimate. Systems may be consciously or unintentionally designed in ways that can shift the prevailing political balance and can make some processes, or some actors, more visible than others (Berg and Bowker 1997; Bowker and Star 1999). For instance, Bowker et al. (1996) mention that the "classification of death from being "worn out" disappeared from the International Classification of Diseases [in] early [20th] century. After that death could only result from something having gone wrong – a potentially avoidable accident or curable disease and thus a site for state intervention" (ibid, p.352).

One of the most powerful studies highlighting the formative power of informational artifacts comes from Bowker and Star (1999). Their observations of the design of a classification system of nursing tasks show how new information infrastructures fundamentally change both work practices and knowledge. A classification scheme neither destroys nor creates work but it may end up radically reshaping work. Bowker and Star argue that the classification scheme reshapes the nursing work in at least three ways:

Changing comparability- As nursing work gets conducted across different spaces and contexts, a need arises to create a scheme to allow for shared meanings. This allows for more mundane things like communicating with the database but also allows for exchanging research information and communicating with a scientific community. However, high levels of comparability create complexity in managing the system, threatening to destroy the intimacy that exists when the meanings are shared across just a few.

Changing visibility- While the classification scheme gives visibility to some of nurses' tasks, it also creates a residual of tasks relegated to the category of "other" that need to be performed but have not found a place of their own in the classification scheme. These residual tasks, such as administrative work, are performed by many nurses but are still considered outside the nursing norm because of various scientific or political conceptions of what nursing work is. This has the effect of making some tasks accountable while others are no longer included in nurses' professional jurisdiction.

Changing control: By controlling what is considered a legitimate practice, classification also controls who can be a part of the nursing profession and who cannot.

Although artifacts are malleable even when they have left the design realm, and are brought into use, inscriptions both constrain and enable, providing some of the plans for "situated actions" (Suchman 1987). The implications of these are seen when classification schemes are consciously modified to change the status quo. For instance, Seidman et al. (1974) show how classification schemes were altered to lower national crime rates in the 1960s. Modern day search engines too, through their designed configurations, can make certain features and aspects of the web more visible than others (Introna and Nissenbaum 2000).

If the designed artifact can have such far reaching implications for how it can be used, one also needs to observe the dynamics during design to understand why technological artifacts may not be as useful as expected. In addition to the political or economic interests during database *use*, the database may be *designed* in ways that can impose undesired control, visibility, and invisibility. Existing research on information design explores two main factors that create undesirable informational artifacts: (1) unrepresentative design; and (2) conflictual design.

Unrepresentative or inadequate user requirements during database design

Group decision making is supposed to produce more informed and well-researched decisions (Hackman and Kaplan 1974). This idea of collective decision making when translated to the realm of information systems design suggests involving the potential users of the system in design. Several scholars argue that such a participatory design process (a) helps systems designers better understand user information needs, (b) provides expertise about the organization, (c) prevents development of undesired features, and (d) helps communicate system features and constraints to the users (Ives and Olson 1984; Lucas 1975).

Systems, when experienced as too constraining, may lead to workarounds (Gasser 1986; Pollock 2005) and creative interpretations (Berg 1997). Some technologies, however, provide fewer degrees of freedom for adaptive malleability because of their tight coupling with organizational structures (Boudreau and Robey 2005). Kallinikos (2004) highlights Enterprise System technologies as suffering from such inflexibility. These technologies are complex, integrated with a wide variety of systems and processes, and require considerable effort for modifications. Such systems may continue to stay closer to their original intent but have the risk of being completely discarded, as seen in several failed ES implementations (Ross and Vitale 2000), because users have not quite bought into the system. In Boudreau and Robey's study of an ES implementation at a state agency, the management decision to minimize changes to the off-the-shelf ES package led to most users rejecting the system, at least in the beginning.

To prevent such outcomes, researchers have suggested several ways to engage the users and to elicit their participation (Darke and Shanks 1997; Ives and Olson 1984; Newman and Noble 1990; Robey and Farrow 1982), including interaction techniques that allow users to exercise control over their work through the design process (Boland 1978).

Despite the suggested need for participation, few researchers have been able to find any substantial link between participation and user satisfaction. In one analysis, there was a small correlation (0.23 to 0.34) between user participation and their attitudes towards the system (Hartwick and Barki 1994). An alternative explanation for this low satisfaction is provided by researchers who claim that information systems design is a political exercise, with potential for resistance and conflict. This conflict may derail the system design from its intended goals, leaving at least some potential users unhappy with the system, despite their participation in the design process.

Conflicts during database design

A system design process may excite general interest and may sometimes lead to strong resistance among some potential users (Bloomfield 1991; Markus and Bjorn-Andersen 1987; Markus 1983; Myers and Young 1997). Several factors contribute to this resistance, including a general aversion to uncertainty, opposition due to shifting forms of control, differing judgments on appropriate business goals, and unbalanced dominance of certain actor groups during the design process.

Resistance to change is considered 'a universal phenomenon' (Child 1984, p.195). Systems as mediums of change are also likely to generate discomfort and resistance among potential users. However, resistance is enhanced when systems are viewed as shifting the prevailing forms of work and control (Hirschheim and Newman 1988; Markus 1983). The participatory design process is known to generate direct contact of people, evoking emotions of jealousy and competition, especially as different sides want to exert influence (Barki and Hartwick 1994; Robey and Farrow 1982). In the health care unit that Myers et al. (1997) observed, the senior management wished to introduce time-based costing through the health information system, so that they could use this information to get extra funding from the government. This made the health providers highly resistant to the system because they did not wish to be controlled like 'factory workers.'

Conflicts and resistance could also arise when there is a difference of opinion on the strategy that the business should be adopting (Lee and Myers 2004). This enhanced conflict is especially seen in design of enterprise-wide systems that are attempting to re-design the organizational processes and systems in ways that are different from the habitual and accepted ways of doing things.

Another reason why resistance to a system arises is because users have not been involved in the system design. This is a separate argument from the one about user involvement for accurate requirements gathering. In the argument here, the lack of participation and involvement may lead the users to have more hostile attitudes towards the system and thus be less inclined to use it (Hartwick and Barki 1994). This would be especially true in case of systems whose use is voluntary.

Even when users are involved in system design, the political dimensions could be heightened because of undue dominance of the system designers, who need to cater to what they see as the "little people" (Hirschheim and Newman 1991). The designers of the technology shape the machine itself which in turn shapes who consumes that machine and how it would be consumed (Beath and Orlikowski 1994; Woolgar 1991). Woolgar discusses the design of a new computer machine, which involved the users during usability tests but only after the machine had been put in its case so that the users could see a relatively black-boxed artifact with labels like "Warning. Live parts are exposed if cover is removed." Such designers could involve users, but only through token or compliant participation (Kirsch and Beath 1996).

Conflict is not necessarily dysfunctional. Indeed, conflicts, if resolved, may increase the possibility of project success (Robey, Smith, and Vijayasarathy 1993). However, in several cases, conflict and resistance can lead to significant problems in system design. In the Auto Insurance system that Robey et al. (1989) studied, the constant tussle for control between the designers and the user steering team led to a system that significantly lost its usefulness and eventually had to be completely redesigned.

Research Gap: Missing micro-interactions

I have reviewed some of the research that attempts to explain why database systems are not as useful as they are expected to be. The explanations range from digressions during database use to compromised system design. These explanations shed light on the puzzle surrounding database systems. Too often, however, empirical examination of the design and use process depicts them to be motivated largely by a singular interest, such as power (e.g. Myers and Young 1997), or rationality during design (Ives and Olson 1984) or economics during use (Garfinkel 1967). Several researchers have encouraged the use of multiple lenses in examining the IS use and design process, arguing that systems need to be examined both from a political as well as a rational perspective (Franz and Robey 1984; Robey and Markus 1984). However, in most IS design and use studies, interests themselves are treated as static and distinct from the practices and the underlying process that they shape. For instance, Bossen's study of the electronic health records highlights both the coordinating and accountability potential of the records, but assumes that these interests exist outside the realm of the design process.

Interests such as rationality or accountability do shape the design and use process, but they are also defined in the process. Indeed the design process helps not only define interests, but may also help elicit interests that had not been considered initially. In my investigation of a database design process at a university, the actors discussed interests such as accountability and efficiency before the design began, but their meanings remained largely abstract and uncontested until the design process started. It was only during the design discussions, as people saw the contradictions between the interests, that they could understand the implications of each of these interests for the context that they faced. They also became more engaged in pursuing the interest of comparability that had not been included in the initial design discussions.

The interactions and the contradictions between interests were made visible by the artifact that was being designed. This has been illustrated by other scholars. For example, in Bowker and Star's (1999; 1996) study of the nursing classification scheme, the interest of visibility only became meaningful, and the trade-offs clear, when the initial classification scheme ignored certain tasks such as indirect patient care. In the subsequent version of the classification scheme, the nurses included indirect care as a separate category.

Unless one observes the day-to-day interactions of the design process, the contradictions that could be embedded in the system are difficult to see. The contradictions, both as experienced by the actors engaged in the process and as observed by the researchers examining the process, are only made visible when actors interact with each other around the artifact that is being designed, and in this process their interests clash with one another. Such contradictions are empirically observable through a closer look at the micro-interactions among interests, and between interests and the artifact design.

Through my examination of the database system design process at Welldon, a large American university, I want to emphasize the features and functionalities of the artifact; the interests, fears, and desires of the actors; and how all these elements interacted to create a dynamic and volatile design process. My hope is to present a more nuanced view of the design process that highlights its negotiated and contradictory nature, which may partially explain how database systems veer from their original intended goals.

Outline of the Thesis

The rest of this thesis is laid out as follows. I start in Chapter 2 with a description of Welldon, the university where implementation of a consent decree between the university and the Environment Protection Agency (EPA) required a new database system for monitoring the environment, health and safety hazards in laboratories. This chapter also describes my participatory observation of the design process and data analysis techniques.

The three interests of *Accountability*, *Efficiency* and *Comparability* motivating the actors in their design discussions emerged from my data analysis. These overarching interests translated to desires for certain features and functionalities in the database system, as well as fears about them. These three interests form the focus of the next three chapters. In each of these chapters I discuss the overarching interest, the fears and desires for features and functionalities, and the resulting changes to the database elements.

In Chapter 3, I discuss the interest of Accountability, which generated a desire for features and functionalities that could enable control and evaluation, and promote favorable presentation of self so as to prevent sanctions. This interest also created fears about features that enhanced visibility, showed non-compliance, or created new lines of responsibility.

Efficiency is the focus of Chapter 4 and this interest led to a desire for features that facilitated easier data entry as well as analysis and fears about features that increased the required efforts. But such features created fears that data would be over-simplified, and unrepresentative of the context.

In Chapter 5, I highlight the emerging interest of Comparability, which stems from notions of fairness, creating the desire for features that would enable consistent evaluation among constituents. Such features then generated fears that contextual details would be diluted and information would be subject to misinterpretation.

The three interests, their attendant fears and desires, and the features and functionalities are reexamined in Chapter 6. This chapter portrays the contradictions that arise due to the existence of multiple interests and multiple actors. Using causal flow diagrams, this chapter attempts to represent the trade-offs and iterations that become necessary as people understand the implications for them of the emerging artifact. Several factors determine how the trade-offs are resolved and how they worsen. I discuss these factors and the implications for the final database system in this chapter.

This thesis delves into several themes, including those of participatory design, system goals, and risk management. In Chapter 7, I discuss the implications of my research study for these aspects of organizational life, both from a theoretical as well as a managerial perspective. I conclude with the limitations of this study along with thoughts for future research.

II. Welldon: The Database System, the Actors, and my Analysis

The Site

My analysis and findings are based on ethnographic research done at Welldon, a large American research university that accommodates over 10,000 students and a similar number of employees -- mainly faculty members and research and administrative staff. Welldon is known for its cutting edge research and houses some 25 departments and over 500 research labs engaged in a range of established and emerging scientific disciplines.

At first glance, a university is considered to have an "autonomous place in society and the right to choose its members, settle its aims, and operate in its own way" (Balderston 1995, p.2). The structure of universities is much more loosely coupled than that of other professional organizations and the departments are relatively independent of one another.

Mintzberg (1979) characterizes universities as professional bureaucracies composed of an operating core of faculty and researchers and a bureaucratically organized administrative staff. Professional bureaucracies rely on the power of experts. In a university's case, this expertise is provided by faculty and researchers who comprise its operating core. It is hard to formalize the work of this operating core. While faculty members rely on the university to provide a network of colleagues and facilities, they are not entirely dependent on the particular university for their survival and enjoy considerable freedom. Several faculty members, especially in the sciences, get the bulk of their resources from agencies external to the particular university. This makes faculty members relatively loosely integrated in the university set-up, even though they spend considerable time there. A developer in the IT office at Welldon characterized faculty members as "prima donnas" who are "used to being right." He further noted that Welldon did not demand cooperative team behavior from its faculty members.

Despite the relatively autonomous existence of their faculty members, universities are, nevertheless, embedded in their environments and are increasingly accountable to other institutions within that environment. External government and regulatory bodies exert a growing influence on university governance (Connell 2004). For instance, research conducted at American universities is now governed by Institutional Review Boards, grant bodies such as National Institute of Health, US Department of Labor, Environment Protection Agency, and even the US Department of Agriculture. The increasing regulatory scope is largely a consequence of the expanding scale of research -- "both of expensive equipment and geographic spread" (Connell 2004, p.15) – that has increased the risks and hazards that universities engage with and could potentially unleash on the environment.

Internally, universities have functions and offices that closely resemble those of many other organizations, especially at the administrative level. At Welldon, the administrative staff is organized as employees would be in most large organizations. There are boundaries between departments and somewhat clearly identified roles and responsibilities. Within each unit, the staff is hierarchically organized, and the hierarchical influence is made evident when one of the programmers speaks of the senior administrative staff as "those management people."

With the growth in research potential, the bureaucratic component in modern universities is quickly expanding. The supervising administrators within the universities are not unlike the managers in corporations worldwide. They need to coordinate resources and allocate funds most productively. Finally, they need to control research and practice in ways that satisfy the regulatory demands and financial constraints placed on them by boards of trustees and government agencies. Such responsibilities are not just relegated to the administrative domain, but also involve the operating core of faculty and researchers as my case highlights. The case in my thesis illustrates how both administrators and faculty are compelled to tighten administrative controls, especially when facing regulatory threats from external agencies.

The external agency in this case was the Environment Protection Agency (EPA). In 1998, EPA, in a surprise inspection at Welldon, found many minor infractions in its research labs. While the non-compliant practices did not pose any major imminent threat, what concerned the EPA was the lack of a self-sustaining system that would provide the checks and balances to control the potentially devastating hazards[3] commonly found in Welldon research labs. In response to these findings, the senior administrators at Welldon signed a consent decree with EPA and agreed to create a self-sustaining Environment Health and Safety (EHS) Management System over a period of five years. This management system would create a web of roles, responsibilities, and processes that would not only guide Welldon researchers in hazard management, but would also be a model for similar research organizations nation-wide. The system design process started in 2001 and over 5 years, the Welldon community mapped out several components to create environmentally sustainable research practices. At the heart of this management system was a database system that is intended to capture information on location of

[3] The EHS-related hazards form both the input of research activity as well as its by-product. They can take the shape of chemicals, laser, biological or even nuclear components used as part of the research or can be by-products of research in the form of chemical waste, biological waste, or radiation among others. These hazards could pose immediate and long term threats to researchers, community members, and environment – both locally and regionally.

hazards, researcher training, regulatory compliance, and accidents. One of the administrative staff members at Welldon explained the value of creating a computerized database system:

> One thing we must accomplish with this system, that we won't if we are still using paper, is to provide correct and timely information on 1 million square feet of lab space, 10 million square feet of plant. We can't do that without an absolute army of people, [which] wouldn't respect the conditions of research at Welldon and would interfere with lab practice. Having people in labs every day would not serve the interests of the labs.

The EHS database system at Welldon was part of a larger Enterprise System (ES) that was in use for other university operations such as financial accounts and human resources. The use of an ES package was an attempt to harness its benefits while minimizing the risks of implementation. Welldon has operations and research distributed not only spatially, but more important, culturally. Each department has its own set of equipment, and epistemic cultures (Knorr-Cetina 1999). The diverse equipment and procedures in departments come with equally diverse hazards. The hazards of a physics lab's lasers differ from those of radioisotopes used in a bioengineering lab that again differ from the threats of contamination posed by bacteria or mice in a biology lab. The research at Welldon, therefore, comes with myriad hazards that go hand-in-hand with the benefits of knowledge advancement that they bring. The Enterprise System was envisaged as a tool for centrally managing these risks of modern research labs. At the core, it attempted to confine the enormous diversity by having the same forms and fields to capture data across distinct departments and labs.

The EHS database system

The EHS database system, as designed by Welldon's IT staff, consisted of several inter-connected components (shown below):

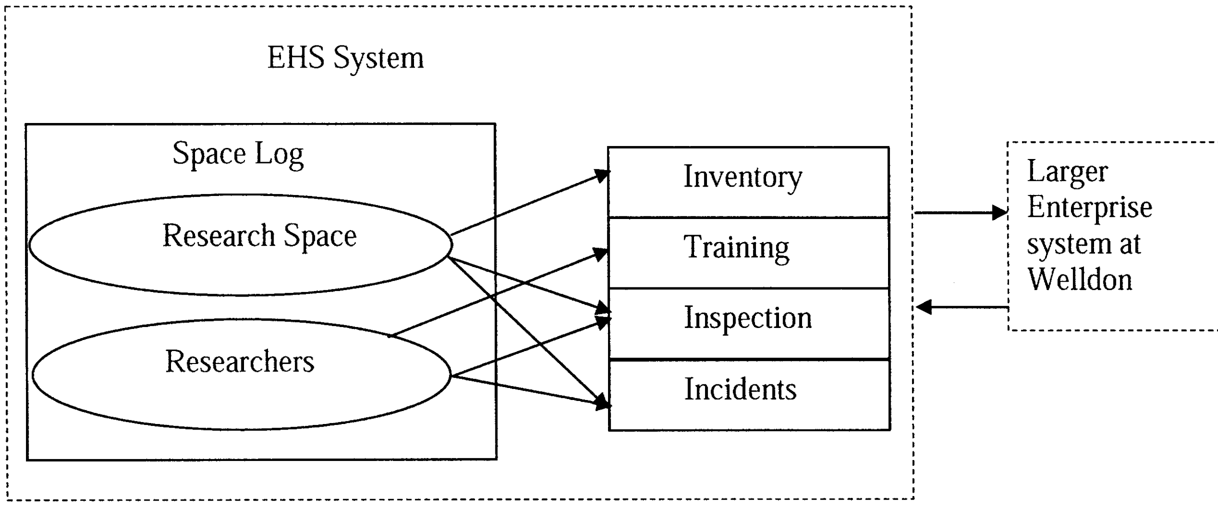


Figure 1: IT Designers' Model of the Integrated EHS Database System at Welldon

Space Log. Welldon had lots of research spaces, and people working in these spaces. The space log was the backbone of the entire system. In order to know something about labs and hazards, it was essential to first record what spaces existed at Welldon, who was responsible for, and who worked in, each space, and most importantly what hazardous materials were used or produced in each space.

Inventory. Every lab had its own stock of chemicals and hazardous materials that Welldon administrators wanted to track centrally. Through the database system, the administrators intended to maintain an inventory of chemicals campus-wide so that the university as a whole could monitor and reduce the use of environmentally hazardous materials.

Training. All researchers were required to undergo legally mandated and system training that was related to the hazards that they were handling. Depending on the research activities, researchers could be required to take periodic training in chemical hygiene, chemical waste disposal, chemical spills, blood-borne pathogens, radiation safety and laser safety. In addition, training on emergency preparedness and safety was required of all researchers regardless of their specific research protocols. The database system maintained training records for every individual engaged in research activity, and was supposed to flag missed training required for safe EHS-related practices.

Inspection system. Under the developing management system, research spaces at Welldon needed to be inspected twice a year for regulatory as well as system compliance. The database in this case was being developed to store information about when inspections were conducted, and any non-compliance observed during the inspections.

Incidents/accidents. Labs could have EHS accidents such as fires or spills. The database was also supposed to record information about these incidents, record information on the persons involved in the incident, and record any follow-up actions.

Each component interacted with the others within the EHS system and also with the rest of the enterprise system at Welldon. For instance, the inspection system interacted with the training system to determine whether lab specific and general training requirements were being met, while accident investigations relied on inspection and training records in order to assess past compliance within the accident area. The EHS system also needed to be integrated with the larger Enterprise System at Welldon. The data about researchers was extracted from the human resources database and the facilities department information needed to be integrated to ensure, for instance, that a broken safety shower found during an inspection of a lab was fixed.

The stated goals of the EHS database system

When the administrators at Welldon made the decision to design the database system, they identified four specific goals. These goals were either explicitly stated before the design decision was undertaken, or were subsequently added to the design initiative. The four goals for the EHS database system were as follows:

(1) To recognize gaps in regulatory compliance. Since the consent decree with the EPA triggered the entire change initiative, the key goal for the database was to help people identify gaps in Welldon's regulatory compliance so as to satisfy the EPA that there was a system to flag and correct any non-compliance.

(2) To continuously improve research practices. The top administrators at Welldon wanted the university not to simply be compliant, but to go 'beyond compliance.' They hoped that the database system would help Welldon recognize good research practices, and improve research practices campus-wide as researchers shared their good practices.

(3) To help Welldon become a safer workplace. Compliance was one goal. But another goal was to ensure that Welldon reduced its accidents over time by recognizing and addressing problem areas, and by creating safer working conditions.

(4) To create accountability and self-correction so that the organization could observe, check itself, and change. Ultimately, these administrators hoped that with time, the database system would replace the need for hierarchical reporting mechanisms to create compliance and safety. The hope was that information entered into the database system would ensure that researchers checked themselves and thus create a safer and compliant environment.

These goals are highly related. Getting people to achieve regulatory compliance would potentially minimize risks posed by research-related hazards, and also improve research practices and accountability. Yet, as I argue throughout this work, these goals were not always compatible in practice.

Actor groups

Organizational decision making is a collective process involving multiple actors. At Welldon, there were some core actor groups involved in the design process. The representatives of these groups often differed in their perspectives because of their distinct roles and responsibilities. This complexity was heightened because each group included ambiguous, multi-faceted and often conflicting interests. For instance, faculty researchers occupy a pivotal position in setting the research agenda in their labs, and are responsible for the safety of the student researchers in their labs. Yet, it is ironic and perplexing for those concerned about managing the hazards in laboratories and assuring safe as well as scientifically productive labs that several faculty researchers are rarely ever seen in the lab, and certainly have not worked at a lab bench during the past several years, despite their prolific scientific accomplishments. Similar to the multiple alliances of the faculty researchers, members of administrative staff too have multiple responsibilities – to their departments as well as to their functional superiors, such as those in the EHS office.

The actors, with their ambiguously defined roles – at least within the context of the EHS-management system – often found themselves at the intersection of two or more alliances. In discussions and debates about the shape of the database system, they recognized – implicitly and sometimes explicitly – that the database system was going to play a role in defining their roles and responsibilities within the management system. The database system had the potential to demand responsibilities that would favor one interest at the cost of another interest.

Some of the most important groups engaged in, and potentially affected by the database system, included the EHS coordinators, members of the EHS office, the IT staff, certain members of the administrative staff, and faculty and student researchers. I next describe these groups in detail.

Departmental EHS coordinators

When the design of the management system started in 2001, one of the first decisions created a new position: Departmental EHS coordinator. EHS coordinators acted as an interface between the university-wide EHS office and the academic researchers, in essence they were expected to deliver the management system within the academic departments, and help ensure local compliance.

Coordinators were primarily of two kinds – those who had been already engaged in some other capacity at Welldon before the EPA consent decree (41 total) and those who were hired especially as a result of the consent decree (5 total). The latter set of people was much younger, more visible in the meetings, and more vocal, and they tended to hang out together. This group was dedicated to their responsibilities as department coordinators, although the same person could be responsible for more than one department.

Coordinators were meant to act as intermediaries between the EHS specialists and the people in the lab. Linda, the internal lawyer suggested that "the [people in the lab] could notice the problems [in the lab] and then discuss them with a [coordinator] 'friend.'" They would be "someone who helps and teaches you, not the police."

Apart from the 5 newly recruited young coordinators, most other coordinators were older and had already been employed at Welldon in other capacities. Jonathon, the coordinator in mechanical engineering, had spent almost 30 years in the department, Sarah in Nuclear Engineering had spent 16 years, and Burt in Chemical engineering had actually spent most of his adult life at Welldon starting as an undergraduate student there. All three -- Jonathon, Sarah and Burt – worked as part-time researchers in their department and were assigned additional duties of coordinator when the position was created. Not surprisingly, these old-timers already had close ties with people within their department.

Some of the newer coordinators were also able to forge strong ties with the researchers in their departments. Brian, a student researcher explained what his department wanted from a coordinator:

> Professor Smith basically did this [keeping up with regulations], and he would have one of his secretaries do the same sort of thing. But the idea was that they wanted someone who did this full time and who has some sort of background in environmental protection or in chemistry, preferably.....we can get someone who, you know, does not even know everything about chemistry, but knows enough so that they can keep our interests in mind, that 'OK, we need to do this, but let's not get ridiculous about this, because I have worked in a lab before too, and I know what's practical and what is not.' But then who can also keep up with EPA regulations, that sort of thing. Just someone who has the right mix of both worlds, so that we look at them and we don't see them as the enemy, like we view the EPA [laughter], but they do know what the EPA expects, so you know, they can be on our side.

Coordinators like Ray, a newcomer at Welldon and hired as a full-time coordinator, were going to provide this 'right mix of both worlds' and still be perceived to be on the side of the departments. It helped that the coordinators were in physical proximity to the researchers' labs. Judy, a student safety representative in the Bioengineering department, explained: "For most day-to-day questions, [our coordinator] is just four doors down the hall."

Such interactions, and the fact that the coordinator receives "authority from and acts on behalf of the [department] Head/Director to carry out EHS programs," forged the relationships between the department and the coordinator. As is evident in the email below from Ray to departmental researchers, coordinators were often willing to protect the departmental researchers from what one of the departmental administrators described as the 'snarling beast,' the EHS office.

> Date: Mon, 25 Aug 14:21:47 -0500
> From: Ray <xxx@xxx>
> To: [lab list]
> A few people have asked me what exactly they should be checking for the fire inspection tomorrow. It is always tough to tell what exactly the inspectors are going to focus on but here are a few items that I would check.
> Make sure that you don't have any chemicals stored on the floor.

> Make sure that the corridor behind the labs is not blocked. There should be a clear path down the length of the corridor alongside the wall with the windows leading outside. [Safety Rep] has been going around and making sure that they are not, but don't put anything in that space between now and tomorrow. Bicycles should not be stored in the building!
> Make sure compressed gas cylinders are secured.
> Make sure eye wash and shower stations and fire extinguishers are not blocked.
> Make sure circuit panels are not blocked.
> Keep lab doors shut. There is no regulatory guideline that says they have to be, but I have been told that this inspector became irritated during an inspection of another building with the doors open.
> Finally if the inspector asks you a question, be polite and answer honestly. It is typically not a good idea to volunteer information, however.
> Thanks,
> Ray

The coordinators also worked very closely with the EHS office. This was especially so with the younger, full-time coordinators who made their presence felt by spearheading various sub-committees that were regularly formed as questions concerning the system-in-design emerged. Alice was active in the EHS awareness sub-committee, Meela was the coordinator representative for the IT design meetings, Ray headed the corrective actions committee and Natasha had been engaged in the inventory software sub-committee. Many of these younger coordinators championed the cause of environment, health and safety within their departments and worked to create a workable and appropriate system of processes and guidelines.

Since the position of EHS Coordinator was a recent creation, the boundaries of the role were still in formation and thus particularly ambiguous. At the time of this research, the coordinators were engaged in inspections of the lab spaces within their departments and ensuring that the researchers completed required annual training. The various systems[4] being created (i.e., training, inspection, inventory, and incidents) were to shape

4 It is hard to disentangle the management system on paper and the database system that is a representation of the management system. As the database system comes into greater use, it may diverge from the practices

the development of the coordinator role, specifically how much of their time would be spent entering and maintaining data and how much of the coordinators' time would be spent ensuring that others in their domain were fulfilling their system obligations. The coordinators contributed a particularly strong voice in the design process.

EHS Specialists

Prior to the creation of the management system, the EHS office at Welldon consisted of five groups of specialists who managed different domains of hazards and regulatory compliance. These five groups -- bio-safety, environmental, industrial hygiene, radiation, and safety -- were organized as separate hierarchical silos. Their interaction with each other and with the researchers was limited to expert advice and training on an as-needed basis.

With the creation of the management system, the five groups were merged into one organization. While the specialists retained their expertise and continued to offer on-request support to departments, they also took on several roles under the new management system. Specialists now had to forge a close partnership with each other and with the departmental coordinators.

The specialists were expected to provide the coordinators with links to the EHS expertise residing in the EHS office during emergencies, through training, and through emerging guidelines on regulatory compliance. During an emergency such as a spill or contamination, the specialist assigned to the department was either supposed to handle the crisis personally or direct the situation to a more appropriate specialist. Different specialists designed training programs around their expertise, to be taken either live or on

---

although the two would potentially continue to interact with and influence each other. In the period of my study, the two were being co-created, each shaping the other, and thus difficult to separate.

the web. They had also written standard operating procedures across hazards ranging from extension cords to air quality compliance. Finally, specialists were supposed to help the coordinators during special events such as those involving introduction of new equipment, or changes in experiments.

The specialists were encouraged by the EHS management to see themselves as customer service providers. Frequently, they faced criticism from departmental coordinators for not providing adequate service. At such times, members of the EHS office rallied together, but were also urged to be more sensitive to the departmental needs. In one such meeting organized to discuss the EHS group's vision, Michael, a senior director in the EHS office stressed this customer service as he wrote on the board:

> Start Doing: get back immediately, communicate more, provide a backup lead contact.
> Stop Doing: ignoring requests
> Reinforce: solicit input

Throughout the EHS office, and especially at senior levels, there was recognition that the EHS office would be responsible for the success or failure of the management system. Consequently, any continuing problems and crises arising during the design of the system had become their responsibility. In fact, several members of the EHS office had become the champions of the management system. They initiated meetings, drew process maps, and created organizational charts when not engaged in their specialist roles. They spent endless hours brainstorming ways to raise awareness about the management system and the regulatory requirements. They agonized over the color and size of the posters, and where these posters should be placed on campus. They presented prototypes, designs, queries, and concerns in various meetings scheduled to discuss the design of the management system. Even when they didn't themselves present at meetings, they were the ones soliciting presentations from other groups. They also provided guidelines to the coordinators about how often to conduct safety meetings within their local domains, how to organize inspections, and when they should be soliciting the department heads' input.

Their leadership position in the design of the EHS management system had made the EHS specialists particularly influential, especially in the IT design process. While the requirements for the database system were discussed in several meetings which included representatives of all actor groups, some of the weekly meetings held with the IT design team consisted exclusively of members from EHS office. Moreover, the budget requirements and the final approval of the IT design blueprint came from the directors of the EHS office, since they were the ones responsible for the creation of the management system.

Finally, the concern that the EHS specialists felt about the success of the management system was especially evident from their involvement in the inspection system. Members of the EHS office were seen as responsible for the eventual sustainability of the management system. Once a year, all high hazard labs were supposed to be inspected by the EHS specialists. Any exemption from inspection was to be approved by them. The EHS specialists often described the management system as "local control with central oversight." The EHS office was responsible for the central oversight of the local departments. They had to meet this oversight while resisting the impression that they were the "police force." They sought to do this by creating a "partnership" with departmental coordinators and researchers.

The EHS office often diverged in practice from its espoused goals of customer service, local-control-with-central-oversight and partnership. This occurred because roles were ambiguously defined and in the newly merged organization, reporting hierarchies were difficult to discern. The delicate balance between the local and the central often tipped in one or the other direction. So, in some departments, the specialist played a very visible role. For example, Joy, a student in Bioengineering, mentioned how Jane, the specialist, was "always there. I needed help on some chemical disposal and she stopped by." However, in some other departments, the EHS specialist was less visible. On being asked about Carla, their specialist at the EHS office, Helen, an experienced faculty researcher in Civil Engineering looked confused and then admitted that she had never met Carla.

Despite their amorphous roles in an emerging organization, the EHS specialists remained very active in the design of the new system, and constantly steered its direction.

Principal Investigators and Faculty Researchers

At Welldon, there are close to 1000 principal investigators (PI), most of whom control designated research spaces. These principal investigators supervise other researchers, who may be students, post-doctoral researchers (post-docs), or other staff members. The spaces that the principal investigators control also house equipment, chemicals and biological materials, all of which may pose hazards. Given that all spaces are sites for potential accidents and incidents, the question that emerged repeatedly was who was ultimately responsible for the safety in the lab. Most PIs are usually familiar with the dangers associated with their research but are less familiar with rules about how to control these dangers. Therefore, much of the discussion in the first couple of years of the management system design revolved around this question of "ultimate responsibility." Finally it was decided that the PI was the "lynchpin," as Linda, the internal lawyer at Welldon, explained:

> So, while you're defining responsibilities and consequences, make sure you don't relieve the PI of his duties -- you can assign them helpers, but they need to be responsible. There can be a difference between who actually does everything and who is responsible.

There were two main reasons for the long discussions about the responsibilities of the PI. First, as in most other aspects of campus life at Welldon, there was tremendous diversity among the PIs. PIs differed in their research budgets, the amount of space, the number of researchers employed and the kinds of hazards involved in the experiments. Bruno Latour (1987) describes the distinction between the "boss" and a "bench scientist" as follows: the boss spends little time at the bench but is responsible for generating resources for research, while the bench scientist actually conducts research using the funds generated by the boss. At Welldon, some PIs were predominantly bench scientists, others were predominantly bosses, while most straddled the two roles. These different types of PIs engaged very differently with their research spaces and the people in these spaces, some at a distance, some in the midst of things.

Second, and perhaps because of the diversity of the PI engagement, it was impractical to assume that all PIs would handle their EHS responsibilities similarly and would all be willing to assume the "ultimate" responsibility for these spaces. When the possibility of this ultimate responsibility was presented to them, some of the PIs resisted the idea. Russell, a biology professor, thought that the PIs "should not be in the loop." Ron, another PI in chemistry agreed with Russell: "PIs go out of town frequently; sometimes they could be away for weeks at a time." Donald, a PI in Bioengineering agreed that "most faculty are just not interested in the process and you can't get them to be."

The EHS and the departmental staff discussed several tactics to engage the PIs:

> EHS staff member: We "emphatically" tell the PIs that they are the center of the system.
> Departmental administrator: That's how we keep them engaged.

As the discussions about PI's responsibilities continued, the EHS office realized the PIs were more resistant to the increased work requested of them than to the idea of responsibility for their research spaces. In a joint committee of EHS administrators, and some key PIs, it was decided that PIs would have the ultimate responsibility but they would have a support system of helpers who would maintain data and conduct the routine prevention and surveillance. Steve, a coordinator in Biology, thought that the PIs "know in general the standards that people are being held to…if they hear about all the support for them they will be engaged. The trick is having them [in the design committees] once."

Of course, the support staff for a PI and his or her lab raised additional questions about who would ultimately be responsible if, for example, the data were inaccurate and if a required follow-up action wasn't taken:

> PI: Is it your plan that the PI will take responsibility to make.. notices [for late or missed training for personnel in their labs] turn into training? I guess I'm asking, where does the buck stop?
> EHS staff: with the coordinators and [student safety representatives in labs].
> PI: I see that as the job of the coordinator.
> EHS Staff: I think the coordinators should have the option to decide their role in this.
> EHS Staff2: Would you be comfortable with your coordinator going into your lab and telling people to get trained?
> PI: Absolutely. As a functional note, PIs are *not* interested in being intermediaries.

The PIs, thus, played an important role in the discussions about the system. Even when they were not directly present in the design discussions, their concerns about the boundaries of their responsibility made them highly salient in the choices made about aspects of design.

IT designers and developers

There was a dedicated IT team engaged in developing the EHS database system for Welldon. This team consisted of the following actors: a project manager, who managed the timeline and budget and negotiated with the key administrators; a business analyst, who interacted with users to gather system requirements; the front-end developer who developed the screens, the labels and the flow of steps; and a host of programmers who actually coded and debugged the system. In addition to these people, there was an external consultant who played a central facilitating role and accompanied the project manager and the business analyst to most meetings to negotiate the system requirements.

The IT team's role was a challenging one. The university was old and established, and as participants often mentioned, had a "Welldon way" of doing things. Its members found it particularly hard to accept new rules and new technologies. Thus, the technical designers of this system operated under several constraints.

Many technical discussions began with the Enterprise System software constraints that impeded the designers' ability to provide different kinds of "functionality." At several points, they had to "mod Enterprise System."[5] A lot of these modifications came from the "Welldon way" of doing things. Jack, the business analyst, explained one such "idiosyncrasy" in the way Welldon reported occupational injuries to OSHA (Occupational Safety and Health Administration) that made it essential to modify the embedded code. The code in the Enterprise System software required people to enter their start and end dates of absence due to occupational injury, after which the system would calculate the number of days that the employee had been absent. However, Welldon did things differently. Instead of having the system calculate the days of absence due to occupational injury, Welldon wanted an administrator to manually enter the absent days, just as had been done in the past. Such distinct ways of doing things required the designers to modify

[5] Technical jargon for 'modify' the inscribed code within the off-the-shelf application

the system code so that the administrator could override the system's automated calculation of absent days.

The requirement to integrate the proposed system with Welldon's existing infrastructure imposed additional constraints. Integration was considered essential according to Dan, the consultant, because supporting multiple platforms "makes it harder to train people... [and] it means [that] more [software] support [is required]." However, integration meant that data in the EHS system had to adhere to the forms and rules being used by other software systems around the campus.

Further constraints were placed by the Technology team's need to meet the terms of the consent decree with the EPA; university demands for self-reflexive checks and balances; university deference to the scientific research community; and finally the constraints imposed by varying user (researcher and staff) needs. For instance, one departmental coordinator demanded the ability to upload photos on the system for investigations into accidents. Jack, the designer, consulted with the developers and came up with a solution:

> "[In the form for] investigation, we are capturing description and cause analysis. We will attach other kinds of documents, witness statement, photos. We can assign people to the investigation. Once assigned, you get an authorization to view certain things. Approvals are handled offline. We notify people, they approve offline....Such things exist in [ES software], but it is a very sophisticated thing to build."

All these constraints made it difficult for the IT designers to satisfy the "customer." Dan, the consultant on the team, expressed his frustration: "giving everyone everything makes our job really hard, our system slow."

Yet, the customer-service goal was repeatedly stressed in internal IT meetings. The IT project manager urged his team to communicate frequently with the customers. Jack, the analyst, also reinforced this need to communicate with the users in a business requirements meeting with the EHS customers:

> Blueprint[6] is a pretty detailed functional design. [Its] purpose is that we understand your requirements. It is a play back…Things are not set in stone…We want to get blessing from you all. It is like a wood shop: measure twice cut once. We feel we did a little too much cutting last time. [We] want to measure more this time.

While the IT designers were saddled with their constraints and the customer service goals, they also felt empowered to create something that they thought would be beneficial for the Welldon community. An IT team member told me "A lot of things are not required by legal purposes, [nor] required by the EHS office but if they are building a system, [we] might as well give them what they want though it is painful." Such engagement by the IT designers enabled a transition of their role from being entirely customer focused to being a partner with the business.

This partnership was made visible by the highly established and elaborate technology design process. One of the administrators in Chemistry complained to his departmental coordinators in an internal meeting, "In my most cynical moments I am afraid this is being driven by the technology team's schedule and their processing maps, which is backwards." The formal design process involved innumerable requirements gathering meetings with users, writing up high level requirements, circulating thick requirements documents to users, presenting them in committees, creating flow charts, creating formal blueprints, designing screen shots, documenting technical specifications and getting sign-offs. At every step of the way, the latest thinking was presented in a multitude of forums -- one-on-one meetings, small key groups and large broad-based groups. The formality

---

6 Blueprint is technical jargon for the functional design of the ES system which is based on the business requirements.

around the process created an aura of participation that made the users feel they were involved in the whole process. The formality also helped create high visibility for the IT professionals as they were a part of so many discussions all over the Welldon campus. They were able to control the rhythm of work for many people involved in this project since they had the strictest deadlines to follow. A proposed change in the requirements had to be approved by the IT people and go through the "change control" approval process – a highly elaborate and bureaucratic procedure. These multiple, often repeated routines also helped crystallize the IT professionals' thinking about the system. Jack, the system analyst explained that, "it is frustrating for many people that we are repeating [the design] in so many ways. But repetition helps as ideas slowly start coalescing around what is being sold to [the users]."

The IT designers were able to further their partnership through the expertise that some of them developed about the business processes of several diverse departments. IT designers needed to spend a lot of time interacting with different users, legal personnel, HR professionals and technical consultants. Through these interactions, they learned a lot about local practices and cultures. For instance, whenever an EHS official would try and propose a guideline for creating the database inspection module, Dan, the IT consultant, would say very confidently, "I know this. I have talked to at least 10 people and this [design] is based on that."

Other actors

In addition to these four groups of people, some of the senior administrators at Welldon were also influential in important decisions, most notably the budgetary ones. They decided what enterprise system package to use for the database system, and approved organizational roles and the timeline for the system development.

Among the senior administrators, the most prominent was the internal lawyer, Linda, who was specially hired when the consent decree was signed. Linda and her team provided legal guidance throughout the system development. They interpreted the regulatory requirements, directing the system designers on the appropriate format of data, and on what could be visible, what needed to be hidden, and what needed to be purged.

Students were another set of actors here, but they tended to form the bottom of the food chain. They were usually the ones to face the consequences of an accident. They were also usually the ones who were responsible for the accidents. Students, therefore, were the eventual objects of regulation. They needed to adopt practices during their research that were not only safe but that satisfied the regulatory requirements. Following these practices usually meant that they had to put in extra effort that they found difficult to do given their already tight research schedules.

To ensure the day-to-day running of the management system, a new role of safety representative (safety rep) was created. Reps were typically students who ensured adherence to multiple regulations, especially those for "mandatory" training, and the safety requirements embedded in the inspection system that were supposed to guide daily actions such as eating and drinking in labs, wearing safety glasses, disposing of waste, and labeling chemicals.

Most student reps did not willingly take up this position. It was time consuming and took away precious research time. Moreover, several student reps felt that they lacked the necessary authority:

> We will make comments about things that are not quite right and compare it to the state of the lab last time, and see if things we noted last time are corrected, and if they are then it is like 'good job', if not, it is like 'you still need to do this' and ultimately though, you know, we don't have power to enforce anything, that's the professors' job, to make sure that these things were taken care of. So while I can say what I want, or make comments, even in our

> own group, you know, I can suggest that people wear the appropriate safety glasses all the time, you know. That is...if someone gets hurt, I mean, that's [PI's] responsibility, to make sure that things happen, yeah.

Student reps did not have much influence to directly shape the design of the database system but they were expected to report on any irregularities and follow up on correcting those that were found. In this way they played an integral role in shaping the system's use.

Design meetings and forums

Enabling coordination and communication among such a diverse set of actors was a difficult task, one made more challenging because the actors were dispersed spatially across the Welldon campus. These groups also differed in their temporal rhythms – faculty members were on a semester schedule, while staff members were on an annual schedule that hinged on periodic cycles such as training deadlines and regulatory reporting deadlines. Coordination difficulties arose in the scheduling of meetings between the EHS staff and key faculty members. For example, Paul, the senior EHS administrator, found it very difficult to schedule one such meeting even though he claimed to have offered "twenty four dates" and still not found one that could accommodate everyone.

At the same time, not involving everyone was not an option. The EHS officials were extremely careful to solicit input from everyone who could be potentially affected by the system. Linda, the internal lawyer urged all the key EHS staff designers to "clarify that we are not going to *test* our system *on* [departments], but that we are *developing* our system *with* the [departments]." Aaron, the vice president at Welldon, thought that this participation was a "model way of working with the [faculty] to get things done." This culture of partnership, the administrators and designers believed, would create more inputs and ideas and also create a sense of "ownership" so that the system would eventually have few resistors. Stanley, another senior EHS administrator, discussed his belief that during such communication: "we get lots of feedback about what is not working, we have no lack of feedback from [coordinators], they have no trouble telling us about their problems... but that just shows the system is working, they are all engaged." Linda also noted that this expanding communication "has been an opportunity to form relationships -- we are not faceless bureaucrats, we are helping them and they can see that now."

Several committees and forums were formed at Welldon to enhance the communication between the designers of the system and its potential users. Some of the committees were longer lived than others; some met periodically while others met on an as-needed basis. Some committees were formed to discuss special issues that may have arisen at another forum. Most of the temporary committees were very active for the short period that they existed and then faded away as the issues were resolved or lost steam.

For the purpose of the technology team, some of these committees provided a way to gather user requirements. These committee meetings were the collective space where the various constituents aired their concerns and responses to the designs. Paul, the senior EHS administrator, explained the value of these committee meetings:

> When [IT project manager] said that I need one person to represent the users, we gave him one of the users. She came back 2 weeks later and said 'help! get me out. I can't represent these people.' So now as many people go to the [technology] meetings and people from [IT team] go to the committee meetings and I make people vote on requirements.

At Welldon, it was difficult for one user to represent the diversity that existed. Committees allowed a representation of this diversity. Some of the more well-established and regularly convening committees are described below.

Joint committee of EHS and departmental personnel was a committee of members of the EHS office and departmental staff, and intended to allow EHS and IT to share design proposals with departmental staff and coordinators. The fortnightly meetings of this committee were preceded by an email sent out by someone in the EHS office specifying the agenda accompanied by the minutes of the previous joint meeting. These joint committee meetings had a very predictable pattern:

> Lucy Jones comes armed with some flip charts and markers. She turns on the lights in the room, pastes the chart with "action items" from the previous meeting in one corner. She tears off three blank flip charts and pastes them next to the first used chart. Then she straightens out the room, placing the chairs in a class-room style. These chairs get filled by other members of EHS staff who usually arrive first, the representatives from the IT team and the departmental coordinators. The meeting itself proceeds with a line-up of presenters – some from the EHS office, and someone from the IT team – who go to stand at the head of the room. Sometimes there is also a coordinator who has been heading a sub-committee, who goes up to present ideas. Throughout this process, Lucy stands next to the charts, scribbles things in different colored markers but also turns around occasionally to provide her own perspective or to summarize others' perspectives that have been drowned in the cacophony. At the end of the meeting, she reads out the "action items" that have emerged from that meeting and the meeting ends (Field Notes).

Although the purpose of these joint meetings was to share design proposals with the departmental staff and coordinators, these design proposals were discussed and fine-tuned beforehand in other smaller forums. It was only when they were considered more or less developed that they were taken to the joint committee. After the design presentations, feedback was sought and then every big design component needed to be accepted by a "quorum" of at least nine coordinators. Often decisions were postponed to the next meeting because there weren't enough coordinators to make a quorum. Jack, the business analyst on the IT team expressed his frustration and amusement at the voting process: "talk about decentralized process! The guy gets out [of the room] to call on [his] cellphone and the vote gets delayed!"

Departmental committees: Not all the coordinators met internally as a group, but coordinators from the two biggest schools – the School of Engineering and the School of Science -- met periodically. Most of the coordinators who attended these meetings, especially those in the school of science, derived their power from their very powerful departments. Departments like Biology and Chemistry were particularly visible because of the status of their key PIs, their budgetary allocations, and the kind of academic alliances that they shared with several others on the Welldon campus. They also created 70% of the hazardous waste on campus and thus were potentially most vulnerable to danger and the biggest sources of non-compliance. Coordinators of these schools discussed the common issues that they were facing within their own departmental spaces, such as training or safety protocols. But what most bound them together during these meetings were the grievances and jokes that they aired about the EHS and the IT staff. Several minutes of each meeting were spent in coordinator discussions about the "incompetence" of the EHS officers, and their ignorance about the research side of the university. Complaints about the poor service that the EHS office was providing to the departments was typical, like this one from Natasha:

> I find that I spend more time scheduling with my [EHS specialist partner] than I do *with* her. She cancels 99% of the time. She keeps saying she wants to do inspections with me, and I just say okay automatically now, because I know she won't show up.

As the database system gained prominence, these meetings also became opportunities to discuss the "slowness" of the database system and its inflexibility in recognizing the complexity of departmental life. For instance, the coordinators complained that the database did a poor job of identifying the training requirements of the researchers, several of whom spanned multiple departments.

Despite this seemingly adversarial relationship with the EHS specialists, the coordinators involved in these meetings were also continuously engaged in communication with the EHS office and the IT staff in their efforts to create a more realistic system that accommodated their diverse requirements. When issues got particularly contentious, they invited representatives from these other groups to their meetings to convey their concerns and to seek solutions. The coordinators, through the collective voice they generated through these meetings, shaped several business processes and the database system at Welldon, even if they sometimes managed to get only isolated concessions for themselves based on their differential departmental clout.

Committees and sub-committees of the EHS office staff: Members of the EHS office also had several internal committees at various levels of hierarchy. The most prominent of these committees were those of EHS specialists and those involving the senior members of the EHS office. Among other things, these meetings were used to decide what to present to the coordinators in the joint meeting and how to enhance awareness of EHS activities and increase communication with the departmental staff. These meetings were also used to examine the choice of performance metrics on EHS activities, how they were to be evaluated, what they had already achieved, what "gap" remained and how it could be filled. The need for yet another standard operating procedure (SOP) was usually brought up in these meetings, which often spawned more sub-committees to draft the new SOP.

Finally, the ***committee of senior administrators and faculty*** approved the broader project design and goals. This committee consisted of senior administrators from Welldon, senior members of EHS office, and PIs representing different departments on campus. This committee met much less frequently than the others. The asymmetric temporal rhythms of its constituents played a large part in making this committee relatively inactive. Yet, when they did meet – and they were much more active during the initial few years of the management system design – the committee focused on broad EHS goals such as organization structure, budget, accountability, and communication with the Environment Protection Agency. Representatives of the EHS office made presentations to this committee based on their own ideas refined from repeated discussions in other committee meetings. They also used this committee to rally support from PIs who sat on the committee. This committee, even though not very active, played an important role in shaping the management system because of the presence of faculty and senior administrators. In fact, it had the final word on most decisions.

Database fields, features, and functionalities

Meetings and committees proliferated because of the many database features that needed to be designed. Most of these aspects were subject to negotiation and discussion. The arguments about these design aspects revealed the varying perspectives of the actor groups. The decisions on features, both big and small, had the potential to shape the worklife of several actors at Welldon. They included a number of key aspects, including automations, text details, labels, color, authorizations, and information.

Automations

Database systems, like many modern technologies, hold the potential to automate routine business processes. For simple, routine tasks, decision processes could be coded within the technology.[7] In Welldon's case, the design team was unable to describe at the outset what the routine processes would be. The database design triggered debates about the business processes, and both the database design and the business processes were closely tied together as a result. The beliefs about the business processes guided the rules about the database system. However, the business processes had been very loosely sketched out before the discussions on the database system began. The strengths and

---

[7] In the database design literature, such automated rules are called business rules. Once these business rules are agreed upon, the database can take over certain decisions. For instance, in a bank's database system, a business rule could be that a customer with a credit rating of greater than x, and who has had an active account for more than y days would get an automatic credit approval up to an amount equal to z.

limitations posed by the database system then led to several discussions rethinking these business processes – in some cases requiring refinement and tighter definition of existing processes, in others requiring changes to the existing processes, and in yet others leading to the creation of whole new, heretofore unconsidered business processes. For instance, if a lab was vacant, the EHS office had to ensure that it was clear of all hazards before its occupancy was transferred to another researcher. This was an acknowledged but only loosely understood process. Yet nobody could really define the exact process in terms of who would be responsible for overseeing the handover, how long a lab had to be vacant, who would bear the cost of any clean-ups. But the database required a PI to be defined for every research space. So it became imperative to decide how the responsibility would be handled for a vacant lab. The EHS office was compelled to define this process much more clearly because the database had to have an individual named against a research space and there was no room for ambiguity.

Perhaps the most contentious rules of automation involved 'notifications.' Notifications would take the form of an email that would be sent to the intended recipient. These notification emails could be about a non-compliance, a completed inspection, an accident or a missed training. The notification emails could be automated, that is, the system would be set up to trigger an email following certain events. For instance, if John had to take chemical hygiene training on April 1st, and there was no record for John having completed the chemical hygiene training by midnight of April 1st, then the system would send an email reminder to John that he was overdue on his chemical hygiene training. The obvious questions around notifications then were about when these notifications had to be triggered: Was the initial email notification to be sent the very minute a person was overdue on training? What time should be allowed to lapse before a follow-up notification had to be sent? Was a human element needed at some point to triage these notification events? At what point was this human element needed? For major accidents, for instance, notification to the PI needed to be immediate; for more minor accidents, PIs needed to be notified within two weeks. But who was to decide what would be deemed a major accident and what was a minor accident?

Text details vs. standardized options

Data field type is always an important decision in database design – should there be a radio button, a check box, a drop-down list, or a text box? These decisions are difficult because they require an understanding of the kinds of information that would be needed, and the uses to which people would be putting the data. The production and usage of information is strongly shaped by the decisions made about these aspects. After all, limiting the information on an accident to some standard drop-down options would restrict the possibility that more details about that accident would be known, at least through the database system. Choices had to be made about data entry options that allowed the collection of details and those that presented the user with some standard entry choices from which to select.

For instance, in describing the non-compliance associated with a lab, the data-entry form[8] could have a text box where the actors would describe their observations in some self-chosen text. So, against the question: "Are chemical containers properly labeled?" a text box could be provided in which users could enter details about a possible non-compliance using their own language. Or instead, the system could provide a list of

---

[8] Form here refers to the a screen-based electronic input interface

possible non-compliances. In the case of chemical container labeling, the options could be as follows: (1) Chemical container(s) found unlabeled; (2) Chemical container label(s) unreadable; (3) Previous chemical container label not defaced.

Sometimes, the choices between field types were made to save "real-estate" on an already crowded inspection form. Dan, the consultant argued "we cannot have questions and checkboxes and notes if we need portrait [layout for the inspection form]."

Often the discussions about field choices were more involved, especially when they were about the choice between text boxes and drop-down menus. Text boxes allowed greater detail and more discretion while drop-down menus allowed closed choices, and quick assessment. With drop-down menus, the user could count the instances of a particular choice and arrive at a number for, say, the labeling violations due to the chemical container label being unreadable. Sometimes, though rarely, the technical constraints helped make the choice. For instance, the injury sub-system needed to have information on the location where an injury or an accident occurred. A drop-down menu of all the locations at Welldon would have enabled the EHS officials to assess locations that were most prone to accidents. However, to create such a menu of locations meant that every space on the huge Welldon campus needed to be mapped. The absence of such a roster of spaces at Welldon meant that such a drop-down menu was not possible. In this case a decision was made to create a text box to capture locational information about an accident.

Even when a drop-down menu was thought to be the best option for a database field, further discussions on the "default status" become necessary. Default status is the original option that the drop-down menu holds when an electronic form is used.[9] Drop-down options for every non-compliance needed to have a default value. For example, in a question that asked "Are current emergency telephone numbers and flip chart posted in a conspicuous location?," a decision was needed about whether the default non-compliance would be (1) "Emergency information missing" or (2) "Emergency Phone Numbers not current." These decisions meant a thorough understanding of the kinds of non-compliances found in labs, and what were the most common deviant practices.

Language used to describe information (Labels)

Language, and the labels used to describe data fields, define how people interpret the data represented, what they think needs to be entered in the fields, and how they perceive that data will be used. Language also becomes important because it gets easily embedded into the vocabulary of the system, affording meaning. That is why the language used to describe a field was a sensitive issue. For instance, an inspection was supposed to find both good and deviant practices, and the word used to describe the reported practices was "findings." While the word, 'findings" by itself could mean both good and bad observations, the word came to have a negative connotation. As this made some coordinators concerned about an over-emphasis on non-compliances, Alice, a coordinator suggested having another term such as "best practice" to describe the positive practices.

Colors

Color choices in a database may seem to be a minor or trivial design aspect. And yet even these produced their share of discussion. Like language, colors have symbolic

---

[9] Often the default status is easiest for a user to adopt. For instance, a demographic database of an undergraduate dorm may have a question on marital status with a default option of 'single'. This is because most undergraduate students would be single, although options to choose other statuses may be provided.

attributes. In the EHS database system, red became the color of deviance. A person who had missed the required training had their name indicated in red. Therefore, decisions on choosing a color format involved discussion about whether a non-compliance would be flagged by a color such as red or yellow or would it be some other symbol such as "two stars."

Authorizations

Authorizations are a key component of a database system. Authorizations dictate who gets to see what pieces of information, who gets to enter them and who gets to edit them. Within the EHS database system, authorizations decided who got to input the information about a non-compliance, who got to view information about others, who got a restricted view, and who had the ability to change information about non-compliances and accidents once they were entered into the system. Authorizations were instrumental in database design debates because, as I show in the later chapters, they had the potential to shape several practices, roles and responsibilities.

Information to be captured

An underlying theme across the various aspects of the database system was that its design would shape the information that would be captured and consumed with it. The consent decree never spelled out the exact information that was needed to create better compliance. So decisions needed to be made about what was sufficient to capture compliance, and what was going to create an over-burdened system. Was the information on best practices in labs needed? If so, was a separate field needed to capture this information or was there a way to capture this through the existing fields focused largely on non-compliances?

The database features, functionalities, and fields became the platform on which the battles regarding the broader interests were realized, articulated, and fought. For me, as an observer and researcher, the discussions around these design aspects allowed me to understand the otherwise unspoken desires and fears of the different actor groups. My observations in the later chapters highlight in greater detail the discussions around the database aspects and how they reflected, reinforced, defined, and redefined actors' interests, fears, and desires.

Research methods

A constantly changing system requires constant observation. It is by observing the small changes, routine problem-solving, and step by step innovation on a daily basis that I gained an understanding of the system design process. Consequently I used an ethnographic method of both observation and interviewing to collect data. Given the very diverse set of actors involved in the system design, I used multiple data sources that I describe next.

IT Office at Welldon. I started my field observation at the IT office at Welldon, where I had a desk and where I spent about a year (from November 2004 until December 2005) following the IT designers as they went from one meeting to the next. For the first six months I typically spent four days a week in the office, although a large part of that time was also spent attending various design-related meetings across the campus. After the first six months, I took a break of two months while the design was in a lull, and subsequently resumed my observations, albeit with reduced frequency of two-three days per week.

The IT designers were the ones developing the system, and all changes that others wished to make to the system had to be navigated through this team of designers. Therefore, the IT office became a natural place for me to begin my observation and acquaintance process. The time spent at this site also allowed me to study how the designers shaped the technical system to incorporate different forms of control, interpreted the "clients'" needs, provided the possibility of reporting to regulators, and responded to the repeated shifts in the stated goals over time. I observed informal interactions among the IT designers, but also observed 23 formal internal meetings that the designers had among themselves as well as 16 meetings that were held with the user communities where the needs and goals of the system were negotiated. Besides observing these formal meetings, I also conducted 12 formal interviews – including interviewing some members more than once -- with the IT staff to understand their decision-making and design processes. Finally I had regular informal conversations (such as hallway exchanges and lunch time chats) with the IT designers to understand their concerns and constraints.

I maintained notes of my observations during the day and spent the evenings typing up these notes into Microsoft Word files, adding more information and detail based on small reminders and jottings that I had added through the day.

Committee Meetings. Once I was familiar with the key actors involved in the project, I got myself included in the email-distribution lists for all the participating committees. This allowed me to know the schedule and agendas of meetings and to attend them when possible. Besides the 39 meetings involving the IT designers, I attended approximately 84 meetings of the kinds that I described earlier (comprising a total of 123 meetings that I attended during my observation period). Of these, I attended the joint committee meetings between EHS and departmental staff bi-weekly, but I also attended science department meetings discussing the system, internal EHS meetings, and meetings of senior administrators and faculty. The distribution of these meetings is described in Table 1. I was a silent observer in these meetings and took copious notes, sometimes verbatim, as people discussed the merits and deficiencies of the design, expressing their desires and concerns for how the emerging database satisfied or did not satisfy their objectives. Often I would stop to chat with people after a meeting, so I could get clarifications about something they had expressed, or reactions that had been left unexpressed in the meetings.

Labs and departments. Since I was interested in understanding how the database system provides information about safety practices in the labs, I wanted to observe the lab inspection practices. Through these observations, I could identify the gaps between how the process actually occurred and how it was being captured in the database system. I accompanied inspection teams on three different inspections to labs in three different departments.

Archival documents. In this process of system creation, many legal regulation documents, process maps, project deadlines, technical blueprints, etc. were generated or reviewed. These objects served to create and sometimes to constrain a shared understanding (Bechky 2003). I had access to more than 200 planning documents that were valuable tools for understanding the shifting requirements and goals of the system. These objects also served as anchors for discussion with key informants. I used design documents, especially the technical blueprints and the proposed screenshots, to see the sequence of changes to the database system. These documents specified the technical details of the database, and described the layout of the screen that the users would see. I could see the smallest changes made to the font and color, and to the sequences as people would click through buttons and boxes on the database system.

Other formal Interviews. Besides my 12 interviews with the IT designers, I also conducted interviews with 14 key personnel (making a total of 26 formal interviews) who were involved in the project, including EHS specialists, Welldon administrators, coordinators, and other external EHS consultants. In these interviews, I asked questions about the database, objectives for the system, how it was going to affect the individual that I was interviewing, how the system compared to others with which they were familiar, and what alternate tools were used elsewhere. I transcribed most of these interviews and then included them with my field notes for subject and conceptual coding.

Notes of, and discussions with, other ethnographers on the team. My own thesis was part of a larger study at Welldon that involved a team of ethnographers who had been observing the change process since the conception of the EPA consent decree. I had access to field notes and oral accounts of these other ethnographers, which gave me valuable historical context on the change process. This process also helped situate my own work within the larger context of the system design process since we met for regular discussions as a team and compared notes on our observations of different parts of the management system. The group ethnography was invaluable in filling several holes in my own observation that would have been inevitable had the project been an individual effort.

Data source	**Number**
Meetings	***123***
– Joint committee of EHS and departmental personnel	– 37
– EHS committees	– 30
– Departmental committees	– 14
– Committee of senior administrators	– 3
– IT meetings	– 39
Interviews	***26***
– IT designers	– 12
– EHS specialists	– 6

Data source	Number
– Departmental coordinators	– 8

Table 1: Meetings observed and Interviews conducted

Data analysis

My analytical approach was interpretive and iterative, primarily employing the techniques of grounded theory (Glaser and Strauss 1967). I coded my notes from meetings and interviews to discover themes. My initial coding was open-ended (Strauss and Corbin 1998), helping me generate several short one-page memos on topics that intrigued me. The memos generated questions that provoked further observations and inquiries with the IT designers, as well as the other participants in the process. Although the memos addressed many topics, for example, organizational issues, professionalization, subjectivity of law, I began to focus on a recurrent theme around the changes made to the database system. I started maintaining a table where I noted changes requested for the database system. My next step was to identify some key features in the database system and map the chronological sequence of changes made to them – what triggered the change, who requested it, and whether it was accepted. This process helped me identify the triggers for the change, which I then started coding. Some of the key requests for changes that I coded were as follows:

Changes triggered in response to requests:

- for information about others
- for information to guard against others' scrutiny
- to define roles and responsibilities
- for faster data consumption
- for faster data entry
- to enable comparison
- to reduce ambiguity in information
- to create flexibility

Requests for change were usually accompanied by a zealousness to create a perfect system, or by strong anxieties. Therefore, as I coded my notes for these triggers, I started also coding for the predominant emotion attached to the request for that change. I coded these emotions as fears and desires when actors either explicitly alluded to their requests in the form of descriptions like "I fear...", "I worry,..", "I want..," etc., or when I could gauge emotions from the non-verbal reactions to certain change requests.

I then tried to identify the key interests that could generate these requests for the changes. The literature on records and information systems also helped me identify interests such as accountability and efficiency. Ultimately, the three interests that I describe in the rest of my thesis – *Accountability, Efficiency,* and *Comparability* -- emerged from this iterative process of coding, data analysis, and literature insights.

The emergent imagined interests

The literature on records that I have described earlier helped me understand the key interests that are usually identified with record keeping. I examined my own notes to observe whether I had evidence of what the literature predicted, and noticed some departures.

Most research on records examines the interests that the records serve during their use after the records are already in existence. This aspect of existing research made my own observations at Welldon different, given that my observations were about a database system that was not already in use but existed only in the design documents, and in the mental models of different actors. The interests that the database would or could serve were, thus, largely speculative in nature. The emotions that accompanied the requests for changes were based on the actors' imagined uses and purposes that the database would or could serve in the future. I describe the antecedent interests in Table 2.

Changes triggered in response to requests:	**Imagined interests triggering change requests**
– for information about others	– Accountability
– for information to guard against others' scrutiny	– Accountability
– to define roles and responsibilities	– Accountability
– for faster data consumption	– Efficiency
– for faster data entry	– Efficiency
– to enable comparison	– Comparability
– to reduce ambiguity in information	– Efficiency, Comparability
– to create flexibility	– Comparability

Table 2: Antecedent Interests resulting in Requests for Changes

The interest of accountability, which I describe as one of the three fundamental drivers of the design process, was clearly articulated and evident in my observations. The consent decree explicitly mentioned the need for greater "accountability' and "centralization." People imagined that the database would enable greater accountability. That is, in the future the database could identify individuals responsible for non-compliance. This, in turn, meant that the individual would bear some sanction for the non-compliant action. One of the major problems of imagined accountability, however, was that this was unprecedented in Welldon's history. The university had a culture of collective responsibility; the database seemed like it would create a very different organization of work. The participants could only imagine what accountability meant, since there never had been any except at the level of the entire organization.

People requested information that would enable them to control others. Requests for changes that would guard actors against others' scrutiny also stemmed from this imagined interest that the database would be used to control and evaluate actions. Both types of requests – requests for information *about* others, and requests for changes to guard *against* others' scrutiny – mapped closely to the purpose of records for control as highlighted in existing literature on record use. The requests for clarifications on roles and responsibilities also seemed to stem from this imagined interest of accountability. People assumed that information would be used for evaluating their performance against what their roles required and therefore wanted to limit any ambiguities in their responsibilities. This particular kind of request perhaps showed much more prominence in my own observations because of the emergent nature of the database system itself. With systems already in use, as was the case with those studied in most literature, the roles and responsibilities, at least within the context of the record system, would perhaps be better defined and thus, the record system would primarily be used to control and to resist the role rather than to define the role as was the case here.

While the existing literature highlights the role of records in creating coordination, I did not witness any substantial discussions about the database system being used to coordinate EHS efforts across the campus. This may have been because the purpose of coordination was seldom questioned. It was not a tacit driver, merely a tacit consensus. People were much more preoccupied with their speculations about control and accountability and did not fear coordination nor resist it.

The first three change requests were easy to categorize as direct products of the imagined interest of accountability. This interest also led to the other change requests within the database system that I discuss next.

Most evident were the requests for changes that would allow both easy data entry and easy data consumption. People wanted and feared accountability, but without spending too much time and effort either to control or to resist. I classified requests for data entry and consumption as products of an interest in efficiency. I also classified requests to reduce ambiguity in information under the interest of efficiency because people assumed that an efficient database would miss detail and context and create ambiguity. Therefore, they needed to look for ways to mitigate such ambiguity.

Finally, people wanted accountability but in ways that would make comparisons easier. This created further requests for changes that would enable comparison. I classified these requests as emerging from the interest of Comparability. I also categorized the last two change requests – requests to create flexibility and to reduce ambiguity -- under the interest of Comparability. Requests to reduce ambiguity in information were a product of an interest in efficiency but also emerged as people imagined that the database would be used for comparison – they did not want any ambiguity when being compared with others, especially if this ambiguity portrayed them negatively. Requests for flexibility again arose as people imagined the interest of comparability. They did not want comparisons that would dilute the distinctive processes that defined a particular group. A certain amount of leeway had to be given in this interest of comparability, resulting in requests for some flexibility in the system.

Thus, the three interests around which I organize my thesis – Accountability, Efficiency, and Comparability – emerged as a result of an iterative process of data examination and theoretical exploration. These three interests were highly intertwined but warranted separate analytical treatment because of their distinct and dominant roles in the design discussions. I turn next to a discussion of each of the three interests.

III: Imagining Accountability through the Database

Most organizations, even those that are not publicly listed, are accountable for at least some of their actions to their immediate stakeholders and to the society at large. This accountability can be contractual, required by some formal contract or regulation, or communal, based on trust in a relationship (Laughlin 1996). Academic institutions cater to a large number of stakeholders, and are also supposed to be accountable to them both communally and contractually. They are accountable to their students and parents who require quality education, to faculty who require research infrastructure, and finally to their local community and external environments which expect safe working conditions at the university premises.

Despite the continuous transactions establishing or seeking accountability, accountability is difficult to enforce at a university given the loosely coupled organization of the university employees. The PI (Principal Investigator) is usually the critical node connecting the work in the laboratory to the legal responsibility that resides in the President and Board of Trustees, and yet several PIs are rarely ever seen in the lab. They know as much or as little as their subordinates have told them. This is a weak link in a loosely coupled organization, in which the PI is at least four steps below the ultimate authorities at the top of this organization. If PIs know only what their subordinates report to them of their activities, what do the upper level administrators, the Deans, Provost, or University President, no less the Chairman of the Board, know about the activities in the laboratory, the experimental practices that constitute the physical danger of scientific research? Accountability is arguably difficult to enforce at a university.

The consent decree sought to change the status of Welldon's accountability. EPA regulators tried to enforce greater accountability from Welldon, and they also expected to see evidence that Welldon was fulfilling the obligations for which it was accountable. Given how challenging it is to measure accountability, EPA left it to Welldon to prove that it was meeting its responsibilities.

When accountability is difficult to establish and enforce, records provide an illusion that it is being managed. We see this in the case of cops' and taxpayers' records (Pentland and Carlile 1996; Van Maanen and Pentland 1994). Given that it is almost impossible to scrutinize every live transaction of the taxpayer, auditors rely on the records that the taxpayers maintain to seek accountability. Pentland and Carlile argue that contrary to the commonly-held perception, the relationship between the auditors and the taxpayers is not one-sided. Taxpayers have enough resources, usually more than the auditors, to present a stylized and clean return, which the auditors use to assess the taxpayers' tax liabilities. Given the limited resources that auditors have, they often have to take these stylized records at their face value. Auditors and cops, on their part, use records themselves to represent the fulfillment of their own responsibilities:

> Auditors' working papers show the steps of the audit, when they were conducted, how audit evidence was collected, what accounts were tested, what inventory was observed and, ultimately, what were the results. Similarly, police arrest records attest to the actions of the officer or officers who make the collar -- the reasons for a street stop, its location, time and special circumstances, the observed or inferred grounds for the charges filed and so forth (Van Maanen and Pentland 1994, p.57)

At Welldon, the database system became the primary means to establish accountability to its stakeholders, including the EPA. The expectation was that it would allow a presentation of suitable evidence that Welldon not only complied with existing regulations, but that it exceeded them. It would thus establish that Welldon was fulfilling its obligations to its researchers, students, and the larger environment, thereby reinforcing the image of Welldon as an excellent institution. Besides helping to establish accountability, the database would also serve as a benchmark for other universities to follow.

Organizations typically have existing relationships of control and accountability where certain actors are accountable to others. An important facet of records is that they shape the extent of accountability that is expected or possible to demonstrate. With changes in metrics used in records, the existing order of control and accountability opens up once again as certain accounts become expected. This is seen in the emergence of cost accounting metrics which enabled new forms of accountability between shareholders and businesses (Power 1996). In this way, the acceptability of accounts is a negotiated order. "It is a process, as much as it is an outcome" (Lilley 1996, p.118). A newly designed database system such as the one at Welldon was expected to not only help establish accountability to others, but also shape what would be considered as adequate forms of accountability.

In this chapter, I first describe the need for accountability at Welldon, and how the database was seen to fulfill this need. The required accountability generated fears of non-compliance and I illustrate how these fears led to changes in the kind of information that was included in the database. I next describe the other desires and fears that the fears of non-compliance led to. These desires and fears were in response to the inclusion of certain fields and features, and led to further changes in these fields and features. For instance, I show how 'authorizations' and 'automated fields' were used to satisfy the desire for evaluation and control, and how 'default options' were used to enhance the fears of new lines of responsibility. I summarize by showing how fields and features that were included to address the fear of non-compliance, and the desire for evaluation and control, led to further fears and desires: the desire for favorable presentation of self, and fears of visibility and new lines of responsibility.

Accountabilities and Control at Welldon

In the prevailing conditions prior to the consent decree, departments were almost completely autonomous, at least from the perspective of EHS practices. With the exception of a few highly regulated departments, most departments had few centralized guidelines to check the research practices that could cause danger and injury to people and property. The staff at the EHS office provided service to the departments as needed, but their relationship with departmental researchers was almost non-existent. Moreover, the EHS office interacted almost exclusively with the laboratory student researchers. Interaction with faculty PIs was much more limited and checkered by the perception of a hierarchical boundary – at least on the part of the EHS staff. Direct control over, or accountability of faculty members would have been almost unthinkable in an environment where EHS staff members were hesitant to call faculty members by their first names and insisted on addressing them as Doctor or Professor.[10]

In the desired social order, the EHS office needed to establish Welldon's compliance with regulations. Since EHS office wanted to establish accountability and compliance with the regulators, its members sought to control the ways in which this would be

---

[10] At Welldon, almost all graduate students, and several staff members, address faculty members by their first names. That the EHS staff members did not address faculty members by their first names underscored the deference they felt towards them. As late as 2006, in the fifth year of the consent decree, the EHS staff members had still not developed collegial interactions with faculty members, further reinforcing the dual structure operating at Welldon – the autonomy of faculty and the hierarchically-bound administrative staff.

demonstrated, most notably by seeking to control departmental practices. This desired new social order involved the EHS office having greater surveillance and scrutiny over departments that so far had not been held accountable, at least to members of EHS.

Often several different forms of control are simultaneously exercised to produce the desired result -- for example direct control, systemic control, control through socialization, or technical control (Orlikowski 1991). At Welldon, given the challenge of achieving control over the departments, the database promised to bridge the gap between the existing and desired social order. The database became a mediating object to provide indirect and technical control in an environment where direct face-to-face control was considered almost unthinkable. In this transactional nature of accountability and control, the EHS office tried to make the departments accountable to them by controlling them through the features and functionalities of the database system.

The database was seen as a vehicle for controlling action by creating information about who was doing what and embedding rules about who could be doing what – that is, working with what kinds of hazardous materials in what spaces, and with what training. While information cannot materially confine a person's actions, the designers of the EHS system, especially those in the EHS office imagined that the information would be communicated to those with authority, research supervisors or department heads who controlled the financial resources and status of laboratory workers (students and technicians).

The two purposes – establishment of Welldon's accountability to the EPA and establishment of departmental accountability to the EHS office – were explicit in the initial discussions on database design. They also triggered the biggest fear that guided the creation of the database system – the fear of non-compliance among actors at almost all levels at Welldon.

Fear of non-compliance

One of the questions that I asked people in all my interviews was what they thought the objective of the management system was. The interviewees almost always highlighted the necessity to clear the consent decree as a key goal. Burt, a coordinator gave me a response that echoed the response I received from several other conversations:

> They are trying to create a system that will allow them to track environment, health, and safety activities at Welldon that will satisfy the consent decree and presumably be transportable to other academic institutions.

Given the importance of clearing the consent decree, the fear that Welldon would fail to meet it[11] weighed heavily in all discussions about the management system design. Since records would provide evidence as to whether policies were being met, database design discussions were even more dominated by this acute sensitivity to how the data would be interpreted by the regulatory authorities. The EPA could find a particular piece of information to be helpful or incriminating. Most actors involved in the design wanted to make a careful choice about what to include in the database and what to keep out of it in order not to incriminate themselves or Welldon in the eyes of the EPA. Even when they decided to include certain fields they wanted to present these in forms that would minimize any legal liability.

The anxiety about legal repercussions was evident among almost all actor groups. Administrative staff at Welldon and the members of the EHS office were worried about

---

[11] An independent audit of the Welldon labs to be held at the end of five years would determine whether Welldon had fulfilled the consent decree or not. The auditors for this would be chosen from an external body of auditors by Welldon administrators and approved by EPA.

liability because they considered themselves directly accountable to the EPA to prepare a process to meet the consent decree. Coordinators and PIs also shared this fear since they did not want their department to stand out unfavorably in an audit. The possibility of legal ramifications often resulted in decisions that were otherwise not very popular. For example, during a discussion on possible actions against researchers who had not fulfilled regulatory requirements, several departmental coordinators presented arguments against penalizing individuals for missed training.

> [coordinator 1]: I don't want to hold up someone who is working supervised in a lab and making an honest effort to get the training they need.
> [Departmental administrator]: I think we need to define "work" in this case.
> [Coordinator 2]: I want to know -- will the EPA be reasonable about this? If they can be reasonable, then we can be reasonable. If not, then we can't, because they'll fine us.
> [EHS senior director1]: It depends on the inspector, I think.
> [EHS senior director 2]: If it looks like an exception, the EPA will say it is okay -- if it is systemic, then they'll get upset.
> [Coordinator 3]: We should make sure to cover our butts and not just hope the inspector is lenient.

Coordinators argued that researchers may have tried to get training but extraneous circumstances such as lack of adequate classes could result in missed training. Such discussions, where people tried to imagine how their data would be interpreted, what kind of inspector would be interpreting it, and whether there would be suitable consideration given to the context were common. Eventually, every piece of information, however useful or impractical, had to pass the legal liability litmus test. Only when it passed that test were other issues considered, creating further complications to resolve.

Often the fear of non-compliance meant hiding any potentially incriminating and incomplete information. One way to mitigate the risk of incomplete information was to eliminate the information altogether, especially if EPA had not specifically asked for it. Indeed, EPA had provided few details on what was to be recorded and thus, several pieces of information that could be particularly incriminating were left out of the system. For instance, the designers[12] decided not to maintain any records of observations from weekly inspections. Records of weekly inspections were likely to be incomplete and also likely to show frequently found observations such as uncapped chemicals, outdated emergency information, etc. Such incompleteness and routine violations would make weekly inspection records incriminating for labs that had not completed their records or that continued to show a pattern of violations. Supporting the decision to not maintain records on weekly inspections, a senior EHS office member argued:

> Since there's no requirement from the EPA for keeping records of weekly inspections, they can't find Welldon to be "not in compliance" if they don't have records. We need to figure out what's best for the campus.

Dates were another way of incriminating Welldon since they could show when a non-compliance was discovered and when it was remedied; consequently showing that Welldon had been "out of compliance for those dates." The designers thus made another decision – not to include any field for dates at all in the database.[13]

In the examples illustrated above, the designers decided to reduce or eliminate information to be stored in the database system, when it could be used to penalize Welldon, as in the case of dates, or when information was likely to be incomplete for some labs and departments, as was the case with the information for weekly inspections. However, fear of non-compliance due to incomplete information sometimes also meant that additional information was needed to fill holes in existing records:

> [EHS director 1]: If we pull up a document that has a problem, we need to show we're addressing it.

---

[12] When I do not specify any particular individual or group of actors, I mean that the decision was taken through a unanimous vote in one of the joint forums.

[13] Of course, as one of the IT designers pointed out, if someone really wanted to check the date when a non-compliance was keyed in, they could because everything in the database is time-stamped at the back-end.

> [EHS Director 2]: If you show improvement, records will never be used against you.
> Linda (lawyer): That's true in principal. EPA has had problems with this, though -- sometimes they are unrealistic about what is considered responsible. But we are not going to be responsible if we don't have enough information to know what's going on -- we will fail to live up to the standards we have articulated and will fail to comply.

As the following section shows, this fear of non-compliance was used to justify other desires for aspects in the database. Of course, these desires then triggered fears of other kinds.

Desire for evaluation and control

Given the fear of non-compliance, several Welldon administrators, especially those in the EHS office, strongly desired to control the actions of others so that Welldon would not be found out of compliance. The departments were most likely to perform actions[14] that would invite trouble with the EPA if discovered, and the EHS office thus wanted information about departments that could be used to control their actions through four mechanisms: verification, prevention, correction, and condemnation. Information on departmental actions would allow the EHS office to verify that suitable processes[15] were being followed. Information about departments would also facilitate prevention since deviance could shed light on more fundamental problems that could be rooted out to prevent future issues. Information would also enable correction since deviances could be flagged immediately and checked. Finally, information would provide the necessary evidence for consequential condemnation. Without any kind of information distinguishing the departments, it would be difficult for the EHS office to recognize who the compliant departments were and who the deviant ones were. Even if there were a way to recognize compliance through the EHS office's informal interactions with the departments, the

---

[14] Such actions could be due to a lack of knowledge or care on part of the researchers.
[15] These processes could be those required by the law or those established in EHS guidelines.

records would support any actions that needed to be taken to either reprimand or commend individuals or departments.

A highly contentious field that highlights this desire for managerial control was what the EHS staff referred to as "consequences." Consequences are penalties issued to individuals for non-compliance with environmental, health, and safety rules and guidelines. For example, according to the safety guidelines, all chemical waste must be stored in designated containers with clearly marked labels, and full containers can stay within the lab for no longer than three days. At that point, the waste container must be moved from its home "in situ," in what is called a satellite accumulation area, to another locale in which it may stay for no more than 90 days, after which it must be shipped off campus. Should a chemical waste container in a laboratory lack appropriate labeling, this constitutes a serious infraction of EPA regulations and local EHS instructions and process. An inspection of the lab would identify this as a violation of the rules. When such a violation is noted in the database, a consequence (e.g. a verbal reprimand, suspension, forfeiture of grants, or expulsion from lab) may also be noted. If a problem is fixed on the spot, no consequences may be recorded.

Information about consequences was highly desired by the EHS office; the staff wanted to create histories of actions taken against individuals who flouted rules. According to the EHS staff, sanctions were necessary for the sustainability of the EHS management system, which was now their principal responsibility. They reiterated in several forums that they promised EPA that they would "consequent[16] *[sic]* those that are exceptionally bad." By seeking information, which in this case was about penalties issued

---

[16] "consequent" became a newly coined word in discussions on consequences. It meant that a consequence had been issued to someone.

within a department, the EHS office hoped to control behavior in the departments. They hoped that a database field for information on consequences would compel departments to penalize deviants which would then promote safer research practices in the labs.

Besides the information on consequences, the EHS office desired several other pieces of information. Indeed, the desired surveillance and control of the EHS office over the departments led to the creation of more than a few fields in the database system, such as fields about who had completed inspection, who had completed training, who had missed either or who had how many non-compliances. All these pieces of information would further aid the EHS office in enforcing greater accountability of the departments to the management system and therefore, indirectly to them. In fact, the fear of non-compliance often justified the maintenance of records about others. Members of the EHS office often resorted to legal arguments when talking about central record keeping. As one of the EHS specialists noted,

> Remember the reason we are doing this -- EPA wants to know how we know who has done training.

The desire for control was not just restricted to the EHS Office. Within the organizational structure, coordinators directly reported to departmental heads and had a dotted line relationship with the EHS office. Some coordinators felt empowered to air their issues directly to their departmental heads and could be assured of departmental support if they found themselves in a disagreement with a PI in the department. Most coordinators, however, felt themselves to be hierarchically subservient to their PIs. They felt that they lacked the authority to direct their PIs and certainly did not have the means to sanction a deviant PI. The formal authority that the PIs had over the coordinators and the implied deference that they commanded prevented such actions. As the design process continued, several coordinators realized that the information in the database system could make the PIs more accountable to them. The written information could substitute for the lack of a formal authority. It could provide them with resources that they could deploy in their relations with faculty and researchers, who otherwise were not answerable to them. In a departmental meeting of the Science coordinators, one of the departmental coordinators demanded more data about a faculty member in his department who he believed was not meeting the requirements for certain chemicals in his space:

> I have a professor now who has been in a lab for three years and he says the chemicals in the room don't belong to him. I have nothing to back me up on this. I want the documents as a backup.

It is difficult to establish whether documentary evidence would actually have helped this particular coordinator, but it provided the coordinator with a *belief* that he could now make PIs more accountable for their actions. Just as certain fields could be used for control and evaluation, certain features and functionalities, such as 'authorizations' and 'automated fields,' also supported the belief that they could be used to create greater accountability. I describe the discussions around these features next.

Databases require authorizations of different kinds. These authorizations determine who gets to see what, who gets to enter what, and who gets to edit what information in the database. These rules can apply to every individual piece of information or to classes of information. At Welldon, these authorizations generally applied to entire fields of information. For instance, there were rules that determined who would get to enter, view or edit non-compliances. These rules were not typically person based, but role based. So a rule could be that the coordinator of Chemistry was allowed to enter or view the non-compliances for his/her department and whoever occupied that role at that time was automatically given the authorizations to do that.

Authorizations could be used in several different ways to control actions and behavior. For example, the EHS office could use the authorizations to directly view departmental actions, and thus control their behavior. For instance, just including the field on consequences would not have helped if the EHS office could not view the information about departmental consequences. By having the *authorizations to view* information about departmental consequences, the EHS office hoped that they would be able to monitor whether consequences were being issued adequately in the departments for any non-compliances.

Authorizations to edit were also used to control behavior – especially by the EHS office. For instance, Catherine, a director in EHS office argued that PIs and students could not edit inspection observations "because it would be too easy to manipulate the records." Coordinators too were prohibited from editing any observations, even if they had themselves entered those observations initially. Once they had entered their observations into the database, and pressed the "submit" button, they could not make any changes to them. Carrie in EHS office argued for this:

> Once submitted to EHS, [coordinators] shouldn't be allowed to back-track [observations] then. Yeah. Because it could be that they talk to someone [after submitting the inspection observations] and they say 'Don't tell them [EHS office] that!!!'

Members of the EHS office realized that they were going to be perceived by the coordinators as the "police" and wanted to prevent the coordinators from conspiring to hide or retract certain observations. Linda in the EHS office agreed with Carrie that the EHS office needed complete knowledge about observations found in inspections, including any changes that had been recorded to these observations over time:

> How do we then know the full sequence [of changes made to the observations] if [we] are only allowed to see the last submit?

Automated fields were also used to control others' actions, especially by members of the EHS office who wanted to ensure that certain actions were being undertaken. Several scholars have described the uses to which technology is put for controlling actions and automating decisions (Orlikowski 1991; Rule and Brantley 1992; Zuboff 1988). In the telecommunications company that Zuboff studied, a computerized information system was deployed to track the jobs to be done, and to assign available technicians to the given job based on an automated calculation of the projected time required to complete it. Such a system was imagined to aid managers in monitoring 'real-time work behavior' as they could see the status of jobs at any time to check what was pending. Orlikowski describes the productivity tools that were mandatory for consultants in the organization that she observed. These productivity tools had embedded in them the standardized methodology that the consultants were to use in their consulting engagements. Just like the information system at Zuboff's site, the productivity tools were supposed to aid easier and more effective control of the consultants themselves and their output. Both at Zuboff's and Orlikowski's sites, individuals found ways to override the rules embedded in the technological systems and resist the projected control. However, managers deployed the systems at both these sites in the hope of greater control and predictability.

The EHS office hoped for similar predictability and control for what the departmental staff could do with the database system. For instance, the database was designed to require a written record that suitable actions had been taken to correct a non-compliance. Tom in the EHS office stressed this:

> I want it built into the system the follow-ups -- what, when, changes, and a verification [that] finding was corrected. It shouldn't clear out of the system until it was checked off – done!

Such automatic responses were to be used by the EHS office to control the coordinators and PIs.

The PIs, in turn, wanted certain automated fields to control the students in the departments, especially for their training requirements that they wanted closely tied with their lab's core research areas:

> [PI]: If they [students] check a particular PI, can they have training courses checked automatically that can't be unchecked?

This particular PI wanted the training requirements to be automatically assigned to students as soon as they identified which PI they were working for. Other PIs wanted similar automatic warnings for the deviant students in their lab spaces:

> [PI]: Can this thing be automated? If someone's registered [as part of my lab], after a month, if they haven't had any [training] activity, can you flag that and send a warning?

Desire for (favorable) information

Through their visibility and potential accessibility, database records lead to potential control by others since a person authorized to view the record can access another individual's accounts of his/her actions. But the increased visibility also allows individuals to provide accounts of their own lines of responsibility in ways that shows that they are satisfying them. Individuals use this visibility to make their positive actions more visible and sometimes find subtle ways to game the system in order to create this favorable impression. Van Maanen and Pentland describe such gaming of the system as follows:

> Producers of records strive to create impressive facades while antagonistic consumers of records attempt to tear them down. Certainly it is possible for clever organizational members to engineer reports designed to give savvy readers a set of incidental clues that allow them to conclude that the organization behaves in a way that it, in fact, does not. Since the signs are taken as incidental, not intentional, they may seem more significant. Presumably coffee stains provide the evidence of late-night labor, sloppy strike-outs the appearance of spontaneity, tidiness the mark of an orderly process, multiple signatures the

assurance of labor intensity or oversight, polysyllabic words the sign of intelligence, numbers and charts the stamp of precision (Van Maanen and Pentland 1994, p.55).

Thus, additional data, or a different form of data, may help generate a more favorable impression of the subject of control. The administrators at Welldon feared the possibility of non-compliance and thus sought ways to present themselves favorably. The EPA mentioned few specific actions that Welldon had to undertake in order to improve safety. The ambiguity of the consent decree left it up to the Welldon officials to show that suitable actions were being taken. Records provided the necessary evidence that such actions were being taken and that Welldon had the expertise to create a management system. They became a vehicle to provide favorable information about Welldon processes. This favorable depiction of Welldon could occur by eliminating information, or by including additional information. When additional information seemed to reflect Welldon advantageously, it was the only course to adopt even when people resisted the maintenance of extra records. The fear of non-compliance along with a desire for favorable presentation, helped things move along even when the person resisting was an important faculty PI, as seen in this case,

Linda (lawyer): We were fined by the EPA for having incomplete records, because it suggested that inspections that weren't documented weren't happening.
Ron (PI): If it is not required by law, then there are too many labs to worry about them keeping individual records.
Stella (Senior Welldon administrator): How do you demonstrate compliance then?

Such arguments convinced the Welldon officials that they needed to allocate enough resources so that a sizeable database could be created that would showcase Welldon's efforts in creating compliance. The proof of the pudding was not really in the eating but in the record that a pudding was made. Whether the system led to any significant safety improvements was difficult to establish and became immaterial. The database would help demonstrate to regulators and other educational institutions the intricacies designed into the management system.

This desire to portray actions favorably also indicated a need to input information that proved that relevant practices were being followed in departmental research spaces. Further, several EHS officials and the coordinators wanted to enter information in ways that established their own credibility. They wanted to store relevant information to prove that they had accomplished tasks demanded of their jobs. Of course, perceptions of "relevant" information varied across coordinators and departments. Some coordinators like Natasha thought that maintaining standard and "objective" lists of non-compliances would enable them to display expertise. When skeptics like Al, a departmental administrator questioned this blind maintenance of records, Natasha echoed the rationale that was provided on several occasions: "to demonstrate to the EPA we know what we're talking about."

The IT designers created fields and features in response to the actors' desires for providing favorable information about their actions. If a particular piece of information needed to be highlighted through the database, the database had to have a field to store that information in, and the features to highlight that information.

One such database feature was 'notifications.' In the Welldon database system, notifications were emails sent to relevant actor groups, automatically triggered by an event such as approaching training date, or manually generated as in the case of an accident. Notifications created accounts of actors' own past actions and of actions that someone else needed to take. They allowed actors to prove that they had done their part and that the ball had passed into someone else's court.

Notifications were especially desired by coordinators who had the difficult task of engaging PIs, many of whom did not like to be held accountable.[17] Most PIs did not like to be overwhelmed by details on who had missed regulatory training in their labs. Nor did they have the time to go follow up after individual students who had missed regulatory training. Similar difficulties were encountered for non-compliances found during an inspection where the PI did not want to be embroiled in fixing all the problems (e.g., getting broken safety showers fixed). Coordinators desired notifications for two purposes: first, they wanted to avoid the criticism that they had failed to identify deviant individuals or actions in the lab; second, they did not want to be saddled with responsibilities that they did not consider as part of their work domain.

> [Systems analyst]: So, if you want to come back, and iterate through the [responses to non-compliances and find that it] didn't get done, or it didn't work, does the [faculty member] get notified again? Or is that good enough? Realistically how does it happen today?
> [Departmental coordinator]: Realistically the [faculty member] won't be involved but it would be nice to keep a record that the [faculty member] was notified again.

In this conversation, the EHS department coordinator admitted that sending reminders to a faculty member would not serve the purpose of getting a required action done. It was necessary, nevertheless, because sending a reminder created a written account that the required task was not the coordinator's responsibility, and that an inspection had been completed and now the onus was on the faculty member to take the necessary steps to correct the observed non-compliances. By providing an account of actions taken, the coordinator transferred the obligation to provide an account of the non-compliance and responsive action to the faculty member. Several such opportunities for information were

---

[17] Most PIs considered themselves to be knowledgeable enough about practices within their labs and in that sense considered themselves accountable for providing a safe, hazard-controlled environment for research. This, however, did not mean that they were formally accountable to someone else for fulfilling this obligation. It was the formal procedures behind this new form of accountability that created resistance among some PIs.

placed in the database with the sole purpose of creating work boundaries and displaying lines of accountability.

Fear of visibility

Even though the database promised an easier way to exercise control, or perhaps because such control was imagined, the design discussions involved some resistance by those who feared the desired social order that the database designers were trying to create. The people most anxious about losing control were the departmental coordinators. In several internal meetings, they complained about the EHS office's scrutiny over them. Meela, one of the coordinators joked about this: "EHS [office] thinks their life will become a database review." Ray, another coordinator agreed: "That's definitely one thing I have noticed. EHS [office] is reluctant to do anything at the departmental level. They need you to get some form."

Control is relational and not absolute. Often the objects of control have enough agency to resist the control so as to shift the power relations. This is what Giddens describes as the dialectic of control:

> Power within social systems that enjoy some continuity over time and space presumes regularised relations of autonomy and dependence between actors or collectivities in contexts of social interaction. But all forms of dependence offer some resources whereby those who are subordinate can influence the activities of their superiors. This is what I call the dialectic of control in social systems (Giddens 1984, p.16)

In the case of Welldon, the coordinators and departmental researchers resisted the control desired by the EHS office, which then led to the tweaking of several fields and features. Some of the more controversial fields were changed or removed as a result of this. One such field was the one recording consequences, initially proposed to facilitate the control of EHS office over the departments.

According to the EHS staff, sanctions were necessary for the sustainability of the EHS management system, which was now their principal responsibility. They thus stressed the importance of recording information about these sanctions or consequences. However, the departmental staff and researchers had been apprehensive about storing information about internal departmental sanctions in a central database. For about two months, this issue generated volatile discussions. In one meeting, departmental coordinators met among themselves to discuss their anxieties about consequences. They felt that the EHS office was using consequences to diminish their own local control in the departments:

> Coordinator 1: I am fearful of EHS going into labs telling people "oh you can do this"...We worked hard to get them to understand the regulations.
> Coordinator 2: I think EHS should be brought in to be more responsible.
> Departmental administrator: they are controlling from afar.

After a few such discussions among the coordinators, they sent a representative who, in a joint meeting with other stakeholder groups, communicated the departmental concerns about consequences:

> We, the coordinators met to discuss this. There were multiple coordinators involved and there is general consensus and strong opinion that we do not want to document consequences electronically. Is it a [regulatory] requirement? If so what is the minimum we can do? Because the less entered into the system the better off in the end. Generally the thoughts are 5-fold: 1) This is too bureaucratic, and 2) too time consuming. Will we have to document more consequences now for [something that is] out of compliance when lots of times we just fix it? 3) Concern that the EHS office will feel compelled to use this data for other purposes. 4) There is no clear [guideline on] consequences [when to issue them]. The auditors may feel there is no cohesion in the system. 5) We don't want drop down menus for selective consequences, if we record them. We want free-form text.

This, and several similar, rather heated outbursts of protest, led to 'consequences' being removed from the electronic database.

Several other features in the database system were also shifted in response to resistance by actors. As some coordinators resisted the automatically required documentation for fixes on non-compliances found in inspections, the joint committee decided that certain people could be exempt from such automatic documentation. Instead, required documentation of such fixes was to be used on an exceptional basis as a way to control certain deviant individuals. A departmental coordinator could choose the researchers who would have an automatic requirement for documentation. These researchers would not necessarily know that they were being subject to this exceptional scrutiny.

Resistance, therefore, brought some flexibility to the system but the flexibility and independence from control only came to those who were more powerful. This power could be had by proving conformity through past behavior. Researchers who were not asked for mandatory documentation of fixes had, in some measure, displayed their commitment and conformity to the management system. However, the deviant ones did not get the option to resist control.

Resistance to control also became substantial when an actor or an actor group wielded power through other means, such as being a highly visible department at Welldon. This visibility could be had by prominence in the research field, grant money raised by the department or through the sheer size of the department in terms of student and faculty numbers. On the basis of this power, one department at Welldon was able to restrict the EHS office's authorizations to view its non-compliances.

At Welldon, Chemistry was one such department that was very large in size, and had some prominent faculty members. Moreover, chemists, although not at all deferential to what they called "the environmental police," considered the environmental and safety regulations as part of the practice of chemistry. Prior to the consent decree, they were one of the only departments that had an established inspection process in place and had been found to be exemplary in the EPA audit. Given that Chemistry had already satisfied most regulators about its safety processes, the EHS group found it difficult to use the threat of the consent decree with them. The prominence of the department further enhanced its power. As a result, the EHS office agreed to provide certain concessions to Chemistry, most notably allowing them to retain a list of internal inspection observations to which the EHS office would not have access. Few other departments, however, could wield similar power, and thus usually had less degrees of flexibility.

Fear of new lines of responsibility

Database systems have the potential to change the existing social order and their design is often undertaken to accomplish this change. Imagining that this change is possible triggers the fears and desires discussed above. Yet, there are several changes that were unanticipated and unimagined at the outset of the database design. These changes may not have been the main rationale for the design of the database and may not have been considered by most designers of the system. Nevertheless, they started becoming more visible as the database system became more evident through its fields, features, and functionalities. What also became visible was the potential of the database system to enhance the existing social order or create a new one, not foreseen by designers of the database system. Such unanticipated consequences[18] of the database system created further desires and fears for different aspects.

---

[18] While the database is being designed, the consequences of the database system are yet to be seen. But as the database started taking shape and discussions about its features began, the imagined uses of the database system became more vivid.

One of the aspects of the database that went largely unnoticed in the earlier stages of database design was its ability to create whole new lines of responsibility. Database design requires unambiguous and clearly defined roles and responsibilities. For instance, the design needs to specify clearly who will be sent the notification email about a non-compliance, which means it also needs to specify who is responsible for fixing a non-compliance. Established roles could be transferred from an existing paper-based system to a database system. Even for these roles, however, the database created the possibility of new activities that had no place in the world before the database. For instance, in the days before the database, the administrative staff in the EHS office monitored whether the departments had completed their paper-based inspection forms. In the new system, the administrators still monitored this completion of inspection, but with new fields that tracked follow-up actions for non-compliances, the administrators now also had to monitor that non-compliances did not go unfixed for too long.

In this way, the database had implications even for those roles with precedence. For the newly established roles, however, the potential of the database to create and define lines of responsibility in unanticipated ways became especially strong. The database started playing a very active part in shaping the activities that the newly defined positions would be accountable for. And as the design progressed, these possibilities became more visible. The process of database design forced the explicit definition of several roles, in response to questions not previously raised. For example, nobody had quite figured out who would be responsible for fixing a non-compliance. In the database system, this responsibility had to be clearly defined in order to direct the notification email to the right person.

[coordinator]: where does the email go on a corrective action? who does it go to?

> [system analyst]: could be anyone.
> [coordinator]: where does the responsibility lie? We say the PI but when it gets down to a specific incident it falls to the [student researcher].
> [system analyst]: for example an eyewash goes to facilities.
> [coordinator]: But who do we assign it to – how [does] it work?

As the coordinators asked these questions that had not arisen previously, George, a director at the EHS office was forced to admit:

> The process? The team still has work to do.

As these questions were raised, solutions were sought and created in the form of new roles and responsibilities. Before the creation of the database system, most of these roles had been either non-existent or very loosely defined. With fields added, someone had to be assigned responsibility for the information to be entered in the field – questions about who would enter it, who would be responsible for monitoring it, etc., had to be resolved.

The database feature that especially triggered discussions around roles and responsibilities was the 'default option.' Most drop-down menus would have an option already selected by default, e.g. the default option for the drop-down menu to note observation on an inspection question could be 'compliance.' Default options would be chosen based on the most probable response and could be changed with a click of the mouse, if the response was actually anything else. Yet, choosing something as default, especially in the case of a drop-down menu that required the identification of an individual for a role, meant creating an implicit assumption that the person specified as default was ultimately accountable for the job. In fact, the lines of responsibility that the default option created usually had no counterpart in the pre-database world.

One such line of responsibility was created by the role of "reconciler" – someone who would be able to verify the names of researchers engaged in any physical space. This was necessary to ensure that these people were trained to work with the hazardous materials used in that research space. However, creating such a role in the database and assigning a specific person to that role was something that departmental actors were worried about because this meant choosing a person from the department who could do this role. When the IT designers proposed in a committee meeting that departmental administrative assistants do this reconciliation, one of the departmental coordinators, Mike put his foot down:

> Mike: you're asking administrative assistants to take personnel tasks.
> [Systems analyst]: how do you clean up data today, Mike?
> Mike: I request from [administrative assistant] an updated personnel list twice a year. But it is a request. Not a fun job.
> [Systems analyst]: but you're doing it. What if you do this same fun job via a computer or phone now
> Mike (very loudly and vehemently): but it is a request -- not a job!
> [Departmental coordinator2 joins in]: lets not put a mandatory stamp on it!

Mike acknowledged that it had always been the administrative assistant in his department who had done the reconciliation for him. But having a role inscribed in the database translated a collegial, perhaps reciprocal, informal and entirely voluntary exchange into something that was officially mandated, something for which the assistant would now become accountable. The potential to create such new lines of responsibility made the database system a source of much anxiety. This ability of the database to highlight new lines of authority did not just affect newer positions like that of coordinator. Even for existing roles of EHS specialists, choosing their names as default options for notifications on certain non-compliances meant more work

Summary

The fears and desires stemming from the interest of accountability are shown in Figure 2 and Table 3. Welldon administrators believed that they needed to be more accountable to the regulators, and that failure to do so would bring strong sanctions. This sparked fears of non-compliance among the administrators that had repercussions for most actors engaged in the design process – directly or indirectly.

One way to prevent sanctions was to present oneself or one's lab or department favorably. Features that facilitated this were welcome by the users, especially by those coordinators who knew their departments to be the better performers.

Fear of non-compliance also led to a desire for control among Welldon administrators and EHS office. But given that the fears of non-compliance and sanctions were also present among the departmental staff, almost everyone desired evaluation of others' actions to prevent trouble for themselves. Therefore, features such as authorizations and automations abounded, and information fields grew in number.

As features enabling evaluation grew, they created a fear of visibility among all. The EHS staff worried about Welldon's visibility to EPA and the departments worried about making themselves too visible to the EHS office. IT designers had to modify several features to accommodate resistance from different sets of actors, including coordinators, faculty, the EHS office, and lawyers.

Desire for evaluation also triggered concerns that the database system was creating whole new lines of responsibility that did not exist previously. Again changes had to be made to the database system to accommodate these concerns. As I show in subsequent chapters, these changes to the database system often had implications for further desires and fears.

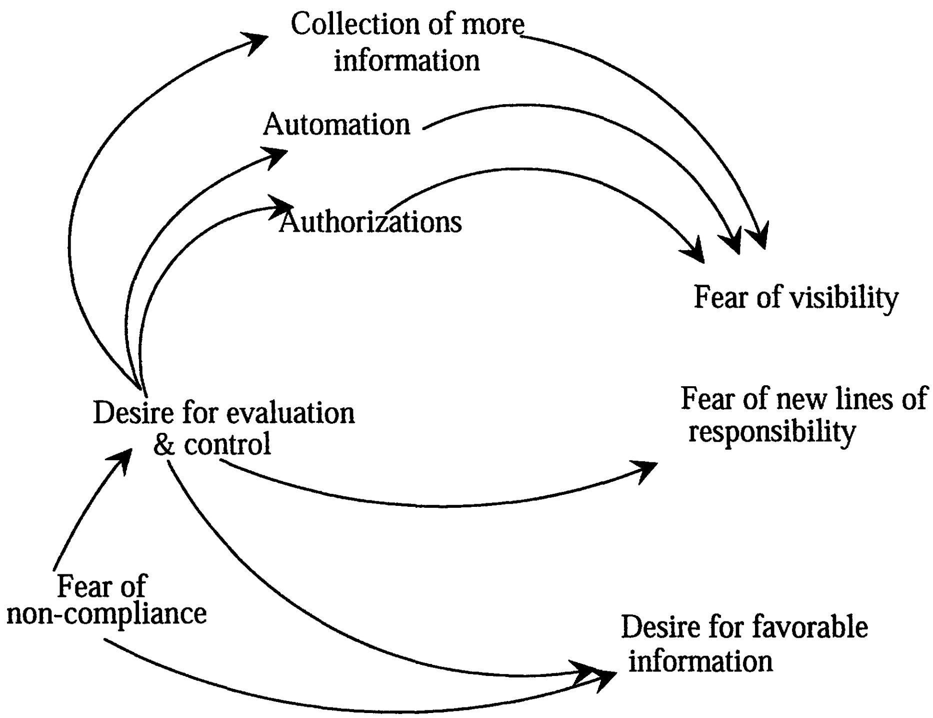


Figure 2: Fears and Desires stemming from the Interest of Accountability

Desires and Fears	Who/whom	Fields and Features
– Fear of non-compliance	– All actor groups from EPA	– Minimal use of incriminating fields such as dates, incomplete information – Options provided (to limit the liability)
– Desire for evaluation and control	– EHS office controlling departments – Coordinators trying to control researchers – PIs controlling labs	– Information about consequences and fulfilled responsibilities – Authorizations – Automated fields
– Desire for (favorable) information	– Welldon and individual actor groups wanting to show the fulfillment of actions to EPA & to each other	– Information about fulfillment of obligations such as completed training, inspections – Notifications
– Fear of visibility	– Departments from EHS office – Coordinators from EHS office	– Appeal to not include the high surveillance fields – Restricted authorizations to view
– Fear of new lines of responsibility	– Coordinators – EHS office staff	– Default options

Table 3: Summary of Actors, Fears, Desires, and Database features stemming from the Interest of Accountability

IV: Imagining Efficiency through the Database

> Efficiency.
> **a** : efficient operation **b** (1) : effective operation as measured by a comparison of production with cost (as in energy, time, and money) (2) : the ratio of the useful energy delivered by a dynamic system to the energy supplied to it (Webster Dictionary)

While accountability was imagined to be an important purpose for the database, most people also hoped that this accountability would be achieved through an efficient process. The people at Welldon wanted to recognize the regulatory gaps without too much effort. They similarly wanted to improve research practices, improve safety, and enhance accountability – all efficiently.

In this chapter, I discuss how the overarching interest of efficiency became one of the drivers of the database discussions. I then illustrate the desires for, and the fears of, features and functionalities that this interest generated. The key desires were for features and functionalities that facilitated easier data entry and analysis. I discuss features such as drop-down menus, automations, default options, and metrics that allowed easier data entry and analysis. The discussions around these features and functionalities strengthened the perception that efficiency was going to be a key driver, and thus generated fears that certain features would lead to oversimplification of information and context. In my final section I illustrate this fear, along with a discussion of those features, such as automation, and default options, that particularly enhanced this fear.

Efficiency at Welldon

The goal of achieving regulatory compliance demanded by the consent decree seemed the most prominent one in the early design discussions. But the regulators involved in the consent decree also acknowledged that managing compliance in an establishment the size of Welldon would be quite an endeavor. Several clauses in the consent decree recognized the need for efficient regulatory compliance:

> Welldon shall provide a training plan employing web-based modules or other uniform training materials and setting forth an *administratively feasible* means of determining who must be trained in administrative, academic and research departments, laboratories and centers (by job title or function), and when training is required.... It must also briefly describe the *automated* system that Welldon has devised to keep track of training records (Extract from the Consent Decree, Italics mine).

As discussions of the design continued, the design team realized that the regulatory requirements were often fuzzy, ambiguous, and open to interpretation. Over time, thus, the focus of design shifted from establishing compliant practices to *proving* that Welldon was in compliance. This was evident in the previous chapter where desire for accountability transformed into a desire to demonstrate this accountability and control. Discussions began to concentrate on ways to accomplish the goal of demonstrating compliance in the least burdensome manner – both in terms of monetary cost and most importantly in terms of time. Researchers, for whom spending time on managing the compliance system was time away from their research, were the most vocal supporters of efficiency. But most other actors also emphasized the value of efficiency.

Both the producers and the consumers of information from the compliance system wanted their tasks done efficiently. The producers wanted to enter information quickly and maintain the database without spending time and effort. Similarly, the consumers wanted to quickly extract relevant information that would then enable them to make quick decisions. Welldon's administrators wanted to demonstrate Welldon's compliance to EPA without expending too many resources. Internally, actors wanted to represent compliance to each other, again with the use of minimum resources. Departments wanted to easily demonstrate their compliance to coordinators and the EHS office. Consumers such as the EHS office and the coordinators, on the other hand, wanted to quickly *assess* whether the departments were actually in compliance, were showing improvement, or were (if possible) exceeding the EPA regulatory requirements. They especially wanted the ability to easily know whether the "problem departments," those that had been found to be non-compliant at one time, were improving or not. Most importantly, this knowledge had to be accessible without requiring the scanning of large amounts of information.

The dual purposes of production and consumption efficiency translated into specific desires for the database system, the two most important being the desire for easy data entry and the desire for easy data analysis.

Desire for easy data entry

As shown in the previous chapter, the realization quickly grew among the EHS officials that written records were essential to demonstrate accountability. Ed, a senior administrator in the EHS office explained:

> The whole reason for the paperwork, if you take the regulators' point of view, [is that] the paperwork shows the work is being done. And that your goal is being accomplished. I recognize that it is a burden on us, it seems like it is just paperwork. But it is to show that we have in fact done our inspections, we have got the people trained, and it is a way of showing that we have done what we're supposed to be doing.

Given this rationale and the importance of having adequate records to prove compliance, it also became essential to minimize the burden of entering and maintaining these records.

The desire for easy data entry was voiced at almost all levels, especially by those who were largely responsible for routine data entry and maintenance. If the database was going to take too much time to maintain, then it would exacerbate the negotiations about who would bear the burden of data entry. When individuals themselves could not directly protest against their increased responsibilities, they had champions among those present in the meetings, who negotiated on their behalf. Faculty, when they were present, responded angrily to demands made of them and their students. They realized that getting the students to manage what several considered "bureaucratic demands" would eat into the valuable research time. For example, one faculty member complained when it was suggested that a student could be given responsibility for a certain data entry task:

> [Student representatives] have scarce time to do the things we are already asking of them, some don't have their own computers. I feel a personal discomfort to tell them here's yet another system you need to learn.

Coordinators were also upset about the increased time and effort with the new process, especially with the inspection process. The proposed inspection process would entail entering data twice. First, the inspectors would carry a sheet of paper that had the inspection questions listed for the lab that they were inspecting, noting their observations on this paper. Once the inspection was completed, they would next send their observations from the paper form to the coordinator who would input them into the computerized inspection data-entry form. Coordinators, who often played the role of inspectors too, were not happy about entering the observations twice – first in the paper-based form and then in the computerized form. Moreover, they wanted to minimize the time that they would spend on the computer with various data entry tasks. Meela, a coordinator argued "we need to be out here [in the labs] and not at our computers."

All these actors involved in the design process recognized the need for demonstrating regulatory compliance, but wanted to minimize the time that they would be spending in data entry, especially for entering the inspection results. To satisfy the desire for reduced burden of data entry, it became important to incorporate several additional features and functionalities such as Automation, Defaults, and Drop-down menus/check boxes. Some of these features were desired to serve other interests as well but this chapter discusses these features from the perspective of efficiency.

'Automation' could be used to control people through embedded rules, as shown in the previous chapter. But automation is also a desired feature of technology because the embedded rules reduce the human interaction with the system, thus promising speedier and more predictable processing. Of course, automation, just like most technological constraints, can typically be overridden. People often manage to work around the triggers and processes coded in the technological artifact (Akrich 1992; Gasser 1986). In Akrich's discussions about the design and use of a photoelectric kit in an African village, she describes the designers' installation of a circuit that would activate during increased power demand, causing the kit to become inoperable, leading to power failure. The purpose of this circuit was to prevent any damage to the kit due to overload. However, in response to villagers' requests to prevent such power failures, the local electrician managed to install a fuse to make the circuit itself ineffective. There thus was a work around what the designers had imagined would be an effective constraint to prevent damage to the kit. But during design, designers often believe that the users will be quite constrained in their ability to generate workarounds.

The designers at Welldon too believed that the constraints embedded in the database system would make users interact predictably with technology. Such predictability, often designed in the form of automations, was actually welcomed by several users at Welldon who hoped that the technology would reduce the mental and physical burden of thinking about a possible course of action and then doing it manually.

Given that the coordinators were most heavily responsible for data entry, they also complained the most about the demands of the database system. The IT designers offered several automations in the database system to appease these coordinators. For instance, they proposed that after every completed lab inspection, and once the departmental coordinator had completed the report of observations found during the inspection, a standardized letter about the inspection would automatically be emailed to the PI who was responsible for the lab. This letter would mention the specifics about the inspection – when the inspection was conducted, what rooms were inspected, who the inspectors were, and what their observations were on various inspection questions. Imagine a coordinator sitting in front of her computer and typing out a letter to the PI stating the inspectors' observations about regulatory compliance in the PI's lab. On the other hand, it would save the coordinator a lot of time and effort if such a letter could automatically be generated by the system and sent to the PI as soon as the coordinator had compiled the report on the lab inspection and "submitted" it to the EHS office.

The IT designers made several other proposals such as getting the system to automatically rate non-compliance on some of the inspection questions as "serious." As I illustrate in the sections below, several automations, though desired by the coordinators for their time-saving potential, also generated anxieties.

'Default options' were another database feature assumed to reduce the data entry efforts. Once the designers had identified the most commonly chosen option for a drop-down menu they could assign that option as the default response, which meant that that option would already be selected for the person entering the data for that particular question, and unless they chose to select an alternative response, they did not have to take any action, at least for that question. Since the option chosen by default would be the one that was the most likely response for that field, it would save the user the effort of manually selecting that option every single time. Several coordinators demanded defaults, especially in the case of choosing a response to inspection questions. For instance, it would be very time-consuming and tedious for the coordinators to select a response to each and every inspection question, especially when coordinators expected their labs to be compliant on most inspection questions. Therefore, the IT designers decided to create a default response for every inspection question: "compliance" (Figure 3). When there were instances of non-compliance, coordinators could go to the drop down menu, and shift their response manually from a default of "compliance" to an alternative response. In the majority of cases, however, the default option would save the manual entry of a response to every question.

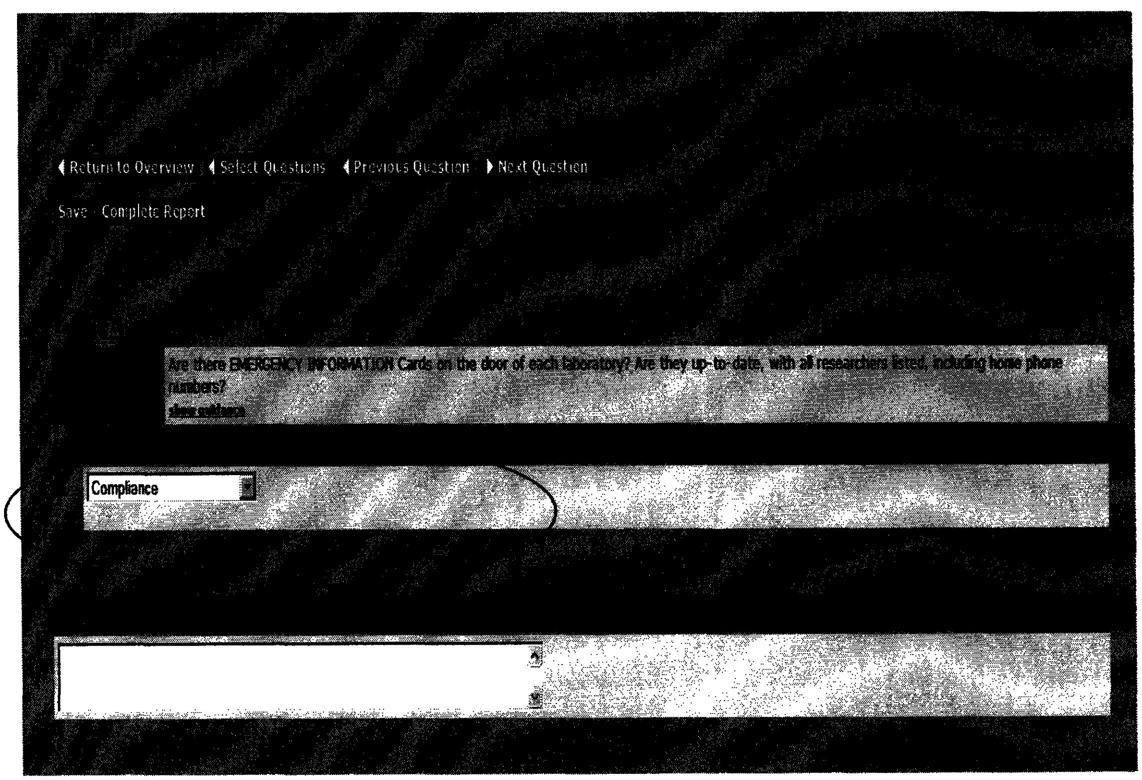


Figure 3: Default Response to an Inspection Question

'Drop-down menus' and 'check-boxes' also aided faster data entry. Entering text clearly takes a lot more effort than a quick check click or selection from a standardized list of options. As Dan, the IT consultant noted,

> Questions themselves will have a very structured format. Basically there would be two levels of multiple choice...A yes answer is "good no problem". Then [there] could be flavors of [responses] other than yes. One is that there is a [non-compliance] but minor enough to be corrected in lab. Example, food in lab [which could be fixed on the spot]. Another could be non-applicable. Bio[logy] doesn't have laser. When [you] really have a [non-compliance], [you will] get a set of multiple choices...What kind of non-compliance?

IT designers like Dan presented drop-downs as time-savers for over-burdened individuals. The drop-downs created an aura of objectivity and efficiency in data entry. Drop-downs were offered alongside the text boxes to capture information that wasn't represented in the text boxes. However, the designers anticipated that over time, as people got more used to the drop-downs, and as the options available through the drop-downs were fine tuned based on the analysis of response patterns, the drop-downs would eventually be the most commonly used form of data entry.

The data-entry form for inspections (Figure 4) was full of drop-down menus and check boxes and option fields. There was a drop-down menu for selecting the response to a question – whether it was a "non-compliance" (needing some corrective action), a "corrected non-compliance" (non-compliance that was corrected on the spot), a "not-applicable" question, or "cannot be determined" (response to the question could not be determined). Following this, if the response to the question was "non-compliance," that is, if there was non-compliance with regards to the specific question, then the next dropdown box required selecting the nature of the observation from a standardized, pre-populated list. For instance, when the inspectors observed non-compliance on personal protective equipment (PPE) practices in a lab, they could choose one of the following options to report their observations: a) Appropriate eye/face protection not worn; b) Appropriate gloves not worn; c) Appropriate foot protection not worn; d) Appropriate body protection not worn; e) Other. The option of "other" in the list allowed presenting those observations that were not otherwise included in the standardized list of non-compliances. If "other" was chosen, then it required a description of the observation in the text box below, otherwise the use of the text box was optional. The designers hoped that, over time, the use of "other" would be largely diminished as the standardized options became more representative.

Following these sets of options that described the nature of non-compliances, there was still another drop-down box that asked what the fix for the non-compliance needed to be and again a standardized list was provided. The last dropdown presented a list of actors who could potentially be responsible for fixing the non-compliance. If the coordinator selected a person from the available options, the system would trigger a whole set of emails and reports notifying the person responsible of the non-compliances found and his/her obligations to correct them. In addition, there were option fields and check boxes. All these features were intended to help the user spend minimum time on data entry. Incorporating these drop-downs was "moving in the right direction" as Jack, an IT analyst argued.

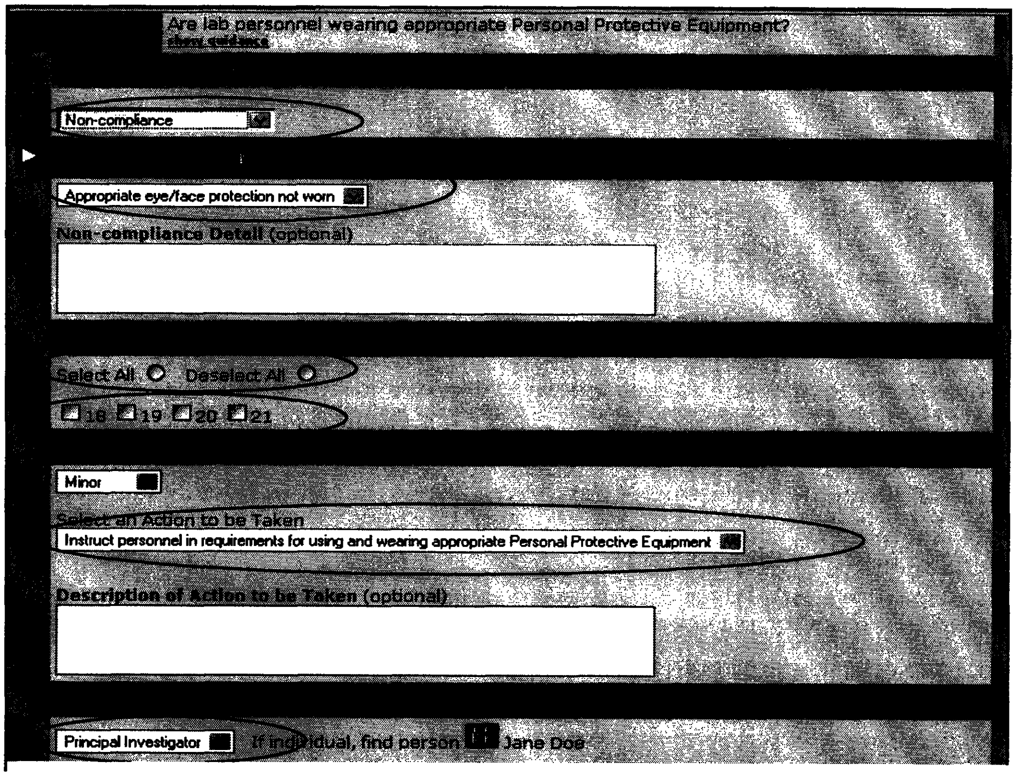


Figure 4: Details for Non-compliance, when found in response to an Inspection Question

Several coordinators complained that these time saving features, although helpful, were not enough. There was a duplication of effort in entering inspection-related observations, first on a paper form and then entering it into the web based form mentioned above. Therefore, coordinators made additional demands to replace the computer-based forms with portable handheld devices. IT designers were compelled to propose a variety of options, including portable computers, laptops, tablet computers, or Personal Digital Assistants (PDAs).[19] Coordinators preferred some options more than others. PDAs were

---

[19] A tablet PC is a notebook- or slate-shaped mobile computer. Its touch screen or digitizing tablet technology allows the user to operate the computer with a stylus or digital pen instead of a keyboard or mouse (source: Wikipedia). Personal Digital Assistants (PDAs) are handheld devices that were originally designed as personal organizers, but became much more versatile over the years. PDAs may have many uses: calculating, clock and calendar, computer games, accessing the Internet, sending and receiving e-mail, radio or stereo, video recording, recording notes, address book, cellphone, and spreadsheet.

the most popular option because of their size and portability. A coordinator provided another reason for preferring PDAs over laptops:

> It is difficult to manage the laptop. I can't sit down on benches because of bio contamination. So [I] need to write with one hand.

All portable options had technical limitations and required additional work by the IT team – consequently they were resisted by this team. Despite these limitations, several coordinators demanded portable options because of their time-saving potential. Paul, a senior administrator in the EHS office rebuked the IT team for not being able to meet the technical requirements for PDAs:

> For lack of putting it better 'as your client I need [you to get your act] together.' If this is not in [IT project manager's] power then I will go to more senior people....We *really* do need to have PDAs. (italics signify emphasis)

The demand for PDAs was so strong that Dan in IT commented, "If we give them [users] PDAs, we will look like heroes."[20]

Desire for easy data analysis

The database system was intended to ease the pressure of entering data for the coordinators and at the same time present a wealth of information. Ease of data entry was welcomed by most coordinators, but it also had the potential to create an overload of information for the EHS office to consume and analyze. Such information overload is a challenge associated with most electronic databases and thus various tools for faster analysis are typically incorporated. Several people in the EHS office felt that such analytical capabilities differentiated the electronic database system from a paper-based system, which, according to Linda in EHS office, "won't tell us anything; it will be too much information....no one will have time to wade through it all." Ed in the EHS office

---

[20] Ultimately, IT designers could not provide support for PDAs, at least not during the time-frame of my observation. This was due to the extensive development effort required to maintain PDAs.

reinforced this view, "technology should increase the efficiency of the system." More zealous actors wanted to use the technology not only to show improvement on regulatory compliance, but also to identify needs that went beyond the regulatory requirements. Several actors in the EHS office, as well as a few coordinators, wanted the data eventually to be presented in a form that would enable faster decision making on resources to be targeted and on accolades or rewards for good performance to be issued,[21] as well as for identifying sanctions that should follow from substandard performance. For such data analysis, metrics were often discussed and included in the database.

Several scholars have written about the illusion of objectivity and impersonality that numbers provide (Grojer 2001; Miller 1992; Miller 1994; Porter 1992). Numbers, and statistics in general, were not always considered as objective. However, over time as administrations represented by the statistics grew in size and complexity, contextual details became difficult to incorporate and assess, and instead numbers came to replace what were seen as untrustworthy details. Porter illustrates this with an example of Napolean's war planning, which required statistical analyses to forecast war supply requirements. As statisticians employed local details, the administration grew increasingly frustrated and decided to use more standardized numbers for administrative convenience. Other fields, especially the scientific fields, also became increasingly more quantified, as calls for replication grew. Finally, numbers created an illusion of objectivity because they were seen as more credible than the often invisible people behind them.

In modern society, numbers are ubiquitous and provide anchors for our ideas from those on democracy to our purchases in the super market. While shopping, we

[21] Just as the database system was supposed to identify the deviant actors, it was also supposed to recognize the high performers

unhesitatingly trust the number flashing on the scale; and in the balance sheets that we see, we form judgments about the corporations that are worthy of investment. While numbers have been influential, with the growing use of records, the diversity of information has increased, leading to greater challenges in communicating and articulating the information that the records are meant to convey. In such situations, standardized numbers and quantified metrics "create *things* which can act and which can be acted upon (a prince, a nation, a social class, an animal species, a microbe, a physical particle, a sickness, an unemployment rate). In each case it is necessary to transcend the contingency of particular cases and circumstances and to make *things which hold together*, which display the qualities of generality and permanence" (Desrosieres 1991, p.200). Indeed, such standardized numbers are said to be the "best hope of settling contested issues" (Porter 1992, p.48)

> "Quantification is in some ways the most structured of discourses, and thus one of the most effective for exorcizing the ghost of arbitrariness from administrative processes. Quantification in politics and bureaucracy helps to promote communication, or rather to reduce ambiguity, by imposing constraints on the issues that can be raised and on what can properly be said about them"

Peter Miller, one of the most prolific scholars on standards, metrics, and their ostensible objectivity, argues that these metrics create the impression that they "would thus free man from instinct and passion and restore the empire of reason" (Miller 1992, p.63). The database would reduce the range of choices for action by eliminating the messy details. Only the distilled bottom line would be needed to spur what was perceived as legitimate action. According to Miller, this "bottom line" creates an illusion of neutrality and objectivity – "set apart from political interests and disputes, above the world of intrigue, and beyond debate" (Miller 2001:382). Miller discusses this objectivity within the context of the principles of standard costing, a practice in accounting that calls for the determination of costs in advance, against which actual costs are compared to assess departures. The standards themselves have usually distilled disparate entities into a common form – for accounting measures this common form is money so that most entities in the firm, including human effort, are assessed in currency units. Espeland and Stevens (1998) define this process of metric creation as commensuration: "the transformation of different qualities into a common metric." Once established, standards created certain norms for efficiency, making the actions of organizations predictable as they sought to come as close to the standard as possible.

As the use of metrics has grown to several fields, new metrics have also been developed that seek to assess the overall health of the organization. In Bloomfield's (1997) case study, the chosen metrics needed to convey cost consciousness and budgetary compliance for the UK National Health Service (Bloomfield and Vurdubakis 1997). Several district level metrics were created that would be combined to create an assessment metric at the national level. Number of admitted patients was one such metric used to calculate the overall organizational health at a district level. However, given the difficulty of assessing this number, the designers of the information system created data definitions that obscured the nuances of the situation. For instance, patients who made intermittent visits to their home had their homes classified as "ward" so that they would still be included in the number for admitted patients. Similarly, many cost figures at the district level were ignored or somehow included in a standardized form in order to create cost figures at a national level. Welldon designers, too, attempted to create similar standardized metrics in order to convey observed goals on legal compliance, regulatory mindfulness, and robustness of the management system. The metrics would represent seemingly objective information not just about the present but about the future as well, about individuals and about departments at Welldon, and would be used to base decisions on.

One such metric (or more accurately, set of metrics) is incorporated in the "Balanced score card." The balanced score card, popularized by Kaplan and Norton (1996), combines metrics on heterogeneous goals to create a composite organizational metric, enabling decisions based on an organization's overall progress. Kaplan and Norton argue that it is difficult to assess the accomplishment of organizational vision and goal statements. They thus suggest that the organization create some measurable overall goals for itself. Organizational sub-units could then link to these overall goals by having their own sub-goals. The organizational balanced scorecard, according to Kaplan and Norton, should have measures on financial performance, customer relations, internal business processes, and organization learning. They concede that business units would have their own distinctive flavors, and thus, should have their own distinctive scorecards alongside the common organizational scorecards. However, as Lipe and Salterio (2000) show through an experiment with MBA students, business units are likely to ignore their unique scorecards and focus their efforts into improving the common organizational scorecard measures. Despite such challenges in using balanced scorecards, the administrators of the EHS system at Welldon wanted to evaluate themselves quantitatively on one. The "scores" for protective equipment non-compliances could, for instance, be incorporated into a score for an overall safety improvement metric. And the safety improvement metric would be combined with other metrics such as customer responsiveness to finally arrive at the overall score for the balanced score card.

Metrics such as balanced score card provided efficient evaluations of the *stock* of the regulatory practices – they would give a snapshot view of Welldon's compliance processes, that is at a point in time, how far was Welldon from achieving the standard for effective practices. But Welldon stakeholders also wanted to assess the progress through *flow* variables – whether and how the changes in performance were occurring over time. An often mentioned term to describe the monitoring of progress was 'trend.' Much data collection was for the purpose of highlighting trends – for example trends in inspection results, trends in accidents and trends in missed trainings. Trends would allow Welldon to identify both improvements and problem areas that ultimately could serve as guidelines for focused action. For example, an increase in missing fire extinguishers would be a cause for concern, a cause to take corrective action in the lab and possibly against an individual. A reduction in the number of missing fire extinguishers would be a cause for celebration. It would be but one "data point" to show that Welldon was improving in its EHS processes. And as George in the EHS office argued, it would be a "very effective and efficient way to identify things and get them fixed."

The desire to monitor trends fueled the desire for data in very specific forms. Without data, the users would only get a vague sense of what was happening. As departmental staff started recording the hazardous chemicals in the database system, and when the EHS office compiled the numbers, they found that the Welldon campus had much higher quantities of hazardous materials than previously thought. In the paper-based system, the EHS office collected information on the inventory of hazardous materials but paper forms were easily misplaced, or misread. The inventory numbers could be incorrectly added up. However, with the computerized database, everyone reported their individual inventories of hazardous materials, and the computer stored these numbers, adding them up. This made the EHS office more confident of the inventory of hazardous materials. Even if they had found that the inventory of hazardous materials was higher than previously believed, they at least felt that they had a more accurate figure, that they had not missed sensitive material, and that in the future they could track how this pile of materials was changing. The IT designers felt that this was a testament to the electronic database's systematic ability to capture more exhaustive and integrated information than was possible through the previous paper-based system. Jim, an IT designer patted himself on the back about the huge return that the electronic database system was already giving over the old paper-based system: "[It is] easy to throw paper. We gave [users and EHS office] an easy thing to do. A good app."[22] The belief was that the database provided more "accurate" measures that could then be used to track changes over time.

Even if there was no foreseeable requirement for this information, it could be immensely valuable for decision-making in the future. Andrew in IT argued:

> If there is a dorm that has fire occurring every 3 months... then it is a potential problem even if not required by law to report. If we track [it] in [the database] system then we have a record of that. In long run statistics we can see where the critical areas are. They help us see the big picture.

Since it wasn't always foreseeable what the data might tell, designers wanted to make sure that they had as much data as possible so that in the future, as needs became clearer, more trends could be analyzed. The possibility of discovering that the designers had failed to include some key data created a palpable anxiety among users. One of the meetings started with several people questioning what they thought was a relentless pursuit of data. Lucy, an EHS staff member, asked in a quiet voice:

---

[22] Technical abbreviation of "application"

> We have to figure out what we're looking for. Data is just an entity. We have to decide what it helps us understand. Data has no value. It is the interpretations.

But very soon, the mood of the meeting had changed. Lucy, who had been largely reflective at the start of the meeting, became increasingly anxious:

> All need to be connected. What if someone asks us who are the new reps -- we *cannot* [she bangs the desk] say. Jack said I can run a quick dirty report but this is not trendable by us. We can see in the report who has generated [a record], but do we know when? Are we capturing how many PIs have gone in the system? To follow up? To look at corrective actions? The system knows it, right? Why don't we have that?

Such discussions often led to renewed efforts to search for more data so that every possible trend could be captured. For instance, the inspection form listed some usual suspects such as coordinator and EHS representative as inspection team members. The person filing the inspection details could then simply check the box against each of these roles to record that these people were present during the inspection. Other individuals not covered by this list could then be mentioned through the text box. Was there a need to mention the PI too in this list even though the PI was rarely present during inspections? Stan at the EHS office considered it necessary. "Maybe we see a trend that when the PI participates [in the inspection], [the inspection] results are different," he argued. It wasn't clear what the data would show, but there was an expectation that sufficient "slicing and dicing" would possibly present information to Welldon officials that they weren't even looking for.

In order to calculate metrics that would then allow the observation of trends, data had to be stored in forms that would allow abstraction, sorting, and summarization. For instance, one could not easily assess the total number of consequences in a department, if consequences were only described textually in the report. If this were the case, then the user of the report would have to go through every inspection report, and identify those text descriptions that appeared to be about consequences. They would then have to count every instance of such text description to evaluate the total number of consequences in the department. On the other hand, if alongside the text description there was also a checkbox for indicating a consequence, one only would need to count the instances of checks to know the number of consequences in the department. Moreover, a system could automatically do this task and would save some human effort.

Since text is often perceived to be difficult to abstract and summarize, quantified data accompanies, and often replaces the details that are available in the text box. The EHS office members who were largely responsible for consuming and making sense of the data wanted the check-boxes, the options, and the drop-down menus that would easily be summarized and sorted into this quantifiable form. With the drop-down options, EHS staff could not only know the exact number of protective-equipment-related non-compliances in a lab, but also the number for specific subsets within that category, for example non-compliances related to appropriate gloves not being worn.

Coordinators, too, wanted data to have some kind of "bottom line", so that they could assess the performance of their labs quickly and "at a glance." Natasha, a coordinator, asked the IT designers:

> "Could we just have numbers -- we have this many corrective actions, this many consequences instead of going into details."

By gaining access to a summarized report on her labs, Natasha expected to be able to quickly assess how her labs had performed, instead of going through reports for each and every lab in her domain. She could then use these summarized scores to distinguish the "good" individuals and labs, from those that were particularly problematic, who would then have certain consequences in the form of more stringent reporting requirements, such as documenting every follow-up action on a non-compliance. The more compliant labs and individuals were rewarded with more flexibility on how much reporting they were required to do.

Fear of over-simplification

While the ease of data entry was often welcomed by people, it also instilled anxieties in some that data entered efficiently led to a lack of details. This meant an increased possibility of misinterpretation and over-simplification. Most features that were desired for their simplicity were also feared for their over-simplification. Also, easy consumption meant making feature choices to enable summarizations and metrics, often at the cost of other potential candidates. All of these could potentially cause excessive control, or could interfere with favorable depiction of accountability. These, thus, created additional concerns and fears.

Automation taking away discretion

Automation was a highly controversial functionality in the database. Although automation, as discussed in the sections above, was highly desired for its ability to automatically generate desired responses in the fastest manner, it nevertheless also restricted human discretion. And while lack of discretion would work in many cases where the business process was well charted, it restricted the ability to handle exceptions. Even in routine cases, actors objected to automated responses for situations that they thought required human discretion.

One of the business rules encoded into the system was that the overall non-compliance rating for a lab based on its inspection could not be "major" if no non-compliance was listed. Such decisions seemed logical. But these simple sounding business decisions were few. Most attempts to automate a business process, like the automatic classification of a non-compliance by hardwiring it into the database system, were met with some anxiety and resistance. Such anxieties were especially displayed by departmental staff and by coordinators, who felt that they would lose control over the data that they entered.

A big point of resistance concerned automatically rating a non-compliance as serious in certain situations. One of the contexts where such automation was to be enforced was when the same non-compliance, albeit minor, was found repeatedly over the course of several inspections. The EHS office felt that such a repeat offense warranted a rating of "serious" even when each instance of that non-compliance was thought to be minor. Such requirements for automation were triggered by coordinators such as Natasha who always requested "objective" criteria for establishing the severity of a non-compliance. But several other coordinators raised objections. Meela, the Biology coordinator asked:

> I don't want to bump up eyewash and unlabelled bottles [to serious] just because it is a repeat [non-compliance] because [these non-compliances] will always be there.

Ed, another coordinator supported Meela by asking what was the 'magic number' of repeated minor non-compliances that would render them serious.

Coordinators such as Ed and Meela felt that a non-compliance could only be deemed minor or serious once its context was suitably examined by a human – something that a business rule hardwired into a technological system simply could not do.

Defaults generating inaccuracies

Even Defaults, which were specifically included to accommodate people's requests for efficient data entry, produced anxieties. When the screenshot for response selection (Figure 4) for inspection questions was shown to the coordinators, the default selection for each question was "compliance." This led a coordinator to worry about possible inaccuracies. Some questions could actually be "not applicable" to the lab, but since the default said "compliance," the coordinators felt they would leave the response as is and not change it to not-applicable. Jennifer, a coordinator argued:

> We'll do what's simplest for human nature. If something's defaulted to 'not applicable,' I will say yeah, why bother with changing it.

Dan, the IT consultant argued back that it hardly mattered that the response to the question was "not-applicable" or "compliance" as long as the lab was not in non-compliance.

> Whole point of management system is to be safe. Does it matter whether we choose it as [not applicable] or [compliance]?

However, coordinators such as Jennifer feared that this would artificially inflate the number of applicable questions in her lab. The score for her compliance would be determined by the number of non-compliances as a proportion of the total number of applicable questions. She would look to be a better performer (having a smaller proportion of non-compliances) than she really was if the denominator, the total number of questions was inflated from its true representation. Stan in EHS office argued, it mattered to have accurate selections:

> Let us say there are 2000 standard questions and only 200 apply to biology, which has 10 non-compliances. But if [coordinator in Biology] included all 2000 [and did not eliminate the not applicable ones], then he has 10 non-compliances out of 2000. 10/200 is different from 10/2000.

Denominators thus mattered, especially when there were fears of non-compliance or legal scrutiny. An over-reliance on efficiency exacerbated these fears, especially given the conjectures about what the EPA was looking for. Stan wondered if, 92% compliance say, was a problem. And Paul in the EHS office wondered if just showing a continuously improving trend was all that was required. In either case, Stan asked "how do we trend things if the denominator is inaccurate?"

The IT designers, in response, included a more rigorous process of selecting the not-applicable questions. They now decided too add another step to the inspection reporting process. In this new step, coordinators would identify those questions that were not-applicable to a lab. Following this selection, coordinators would then be able to print out a list of only those questions that were applicable to their lab. This would then provide the correct "denominator." For instance, in Figure 5, this particular lab had research facilities that did not require the use of hoods or gas cylinders or vacuum pumps, which is why the coordinator for this lab was expected to deselect those questions that pertained to the use of this equipment. Similarly, there were no "particularly hazardous substances" and so the entire section of questions pertaining to these could be excluded.

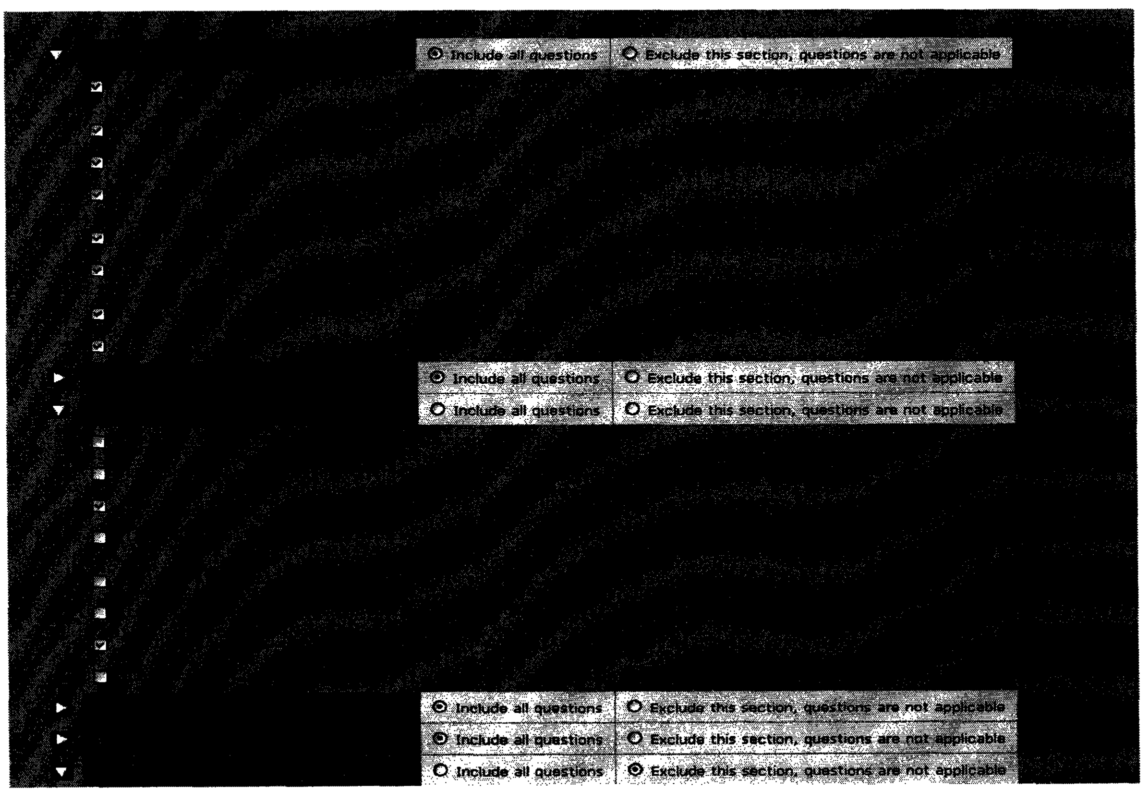


Figure 5: Selecting Inspection Questions applicable to a Lab

This selection of applicable questions, of course, had to be designed so that the data entry could be done efficiently. A coordinator asked if the choices for exclusions based on not-applicable questions could be remembered by the system so that this selection process was not done before every inspection.

The designers decided to use defaults in the additional step that had been included. A question that was considered not-applicable in the previous round of inspection would default to a selection of "not-applicable" for this round too. Again, a flag was raised by yet another coordinator– what if the situation in the lab had changed – for instance, the laser question that was not-applicable to the lab for several years, suddenly had become applicable due to the acquisition of a laser machine – and people forgot to change, or were lazy about changing, the default selection from "not applicable" to "applicable" and so on? The tussle between the desire for efficiency and fear of oversimplification was well highlighted by this never-ending seesaw of arguments.

Misinterpreting metrics

In addition to the anxiety about inaccuracies introduced by people entering the data, there was a fear of misinterpretation. Several coordinators feared that excessive summarization would distort and misrepresent the context and would lead to misinterpretation by people consuming that data. Here the concern, especially among the departmental staff, was about the way the EHS office and the regulators would read the "bottom line" figure. How would one interpret the overall number for non-compliances reported? Or a reported trend that this number was going up over time? Or the inspection report that only presented serious non-compliances and glossed over the details and context of the inspection? As an EHS staff member asked,

> If one of 20 containers was not properly tagged, would that be "95%" [compliance on that question] or a simple [non-compliance]?

Another manager in the EHS office remarked:

> In one lab, suppose 1 out of 200 bottles were uncapped. In a second lab, suppose 100 of 200 bottles were uncapped. In a third lab, suppose 1 of 2 bottles were uncapped. Those 3 labs are very different from the standpoint of compliance, and a simple 'yes/no' would not effectively reflect the circumstances.

When the IT designers proposed that the faculty researchers would not receive the details of an inspection but would instead get a summarized inspection report, Al, a departmental administrator, raised his concern:

> Al: What gets rolled up into this report? What's dropped in the executive summary?
> Systems analyst: There are 45 questions and 40 have no [observations]. So you submit no details on 40. You send the 5 [observations] and details.
> Al: I still need to understand how that 45 gets boiled down to the details. That's where I have concern. The nuances to the [faculty researcher], the culture of the lab, etc. will be lost by the formula.

To satisfy Al's concerns, the IT designers decided to remove the automatic report generation for PIs. Instead, the coordinator would take the bare bones report that the system generated, add their own comments and then hand deliver it to the PI. Even though the need for efficiency was considered paramount, coordinators agreed to make the extra effort in this case.

Fear of over-burden

The extra effort, although considered necessary in some cases, was viewed with concern, especially by the coordinators who were doing a lot of data entry. Their fear of over-burden often outweighed the fear of misinterpretation, especially when they felt that they had already agreed to a lot of effort on their parts. To compensate the coordinators for this data entry effort, the designers made certain choices for summarizations even when there was a risk of misinterpretation.

Tom, a coordinator, noted that a strict reliance on the number of non-compliances would discourage people reporting positive things that were found in the inspection.[23] There was a difference between good practices and practices considered sufficient from a regulatory perspective. One of the EHS staff members explained that "EPA does not call for specifying the age of the container, [but it] was a good practice, [although] not required." But nobody would really bother reporting these positive things if the coordinators believed that the sanctions and rewards were only based on the number of non-compliances, and not on "best practices" that a lab may have had. Moreover, the coordinators feared that these reported best practices would, in fact, be counted among the non-compliances and would then raise the number of aggregate findings. Despite these fears, the designers decided not to include a separate field for positive findings since this would make the system "too bulky."

Concerns of efficiency created desires for certain forms of data and its summarization. However, these choices, through the omission of details, or through an over-reliance on certain kinds of summarizations, could trigger fears related to accountability. As the text-boxes and details were added, the fear of overburden increased. The database was already becoming a mish-mash of text-boxes, automations, defaults, and drop-downs. The choices were a result of multiple negotiations and compromises.

Summary

As seen in Figure 6, and Table 4, the fears and desires led to changes in features and functionalities of the database system. The desire for easy data entry led to the use of

---

[23] The inspection form was to be used to report both non-compliances and good practices. The designers asked the coordinators to report their best practices using the field for non-compliance reporting. They argued that the coordinators could use the additional text field to indicate that the observation was not really a non-compliance but a best practice.

Automations, Defaults, and Standardized fields incorporated in drop down menus, and check boxes. Desire for easier data analysis led to similar features, especially because EHS staff wanted metrics and trends to analyze data quickly. Trends were only possible through metrics, and metrics were largely enabled through the use of standardized fields, again requiring the use of drop-down menus and check boxes. As these features were incorporated, they triggered fears of over-simplification, which led the IT designers to make some changes and put in more contextual details and manual operations. However, given the design, data entry, and data analysis effort required in these options, fears of over-burdening the users of the database system abounded.

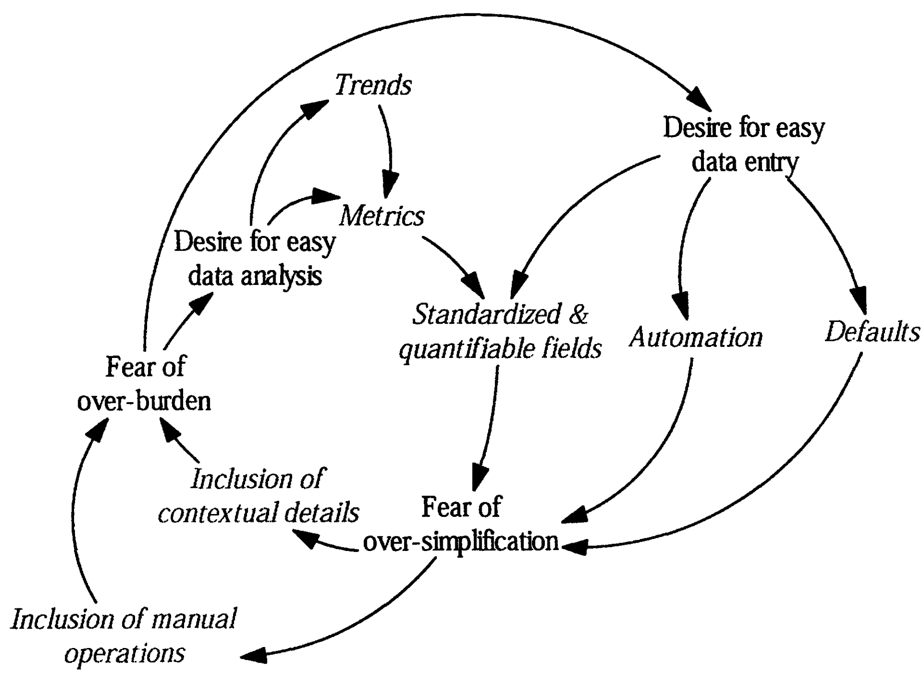


Figure 6: Efficiency triggering Fears and Desires

Desires and Fears	Who/whom	Fields and Features
– Desire for easy data entry	– Coordinators, researchers	– Automations – Defaults – Drop down/check box menus
– Desire for easy data analysis	– EHS office analyzing departments – Coordinators analyzing labs	– Trends – Metrics
– Fear of over-simplification	– Coordinators – Departmental staff – EHS staff	– Contextual details – Manual data entry
– Fear of over-burden	– Coordinators – EHS staff	– Automations – Defaults – Drop down/check box menus – Trends – Metrics

Table 4: Summary of Fears, Desires and Functionalities resulting from the Interest in Efficiency

V: Imagining Comparability through the Database

Departments and entities in any organization are prone to be different from each other. At a university such as Welldon, this diversity was especially pronounced. Universities are engaged in a host of varied scientific disciplines that generate both different kinds of hazards, and different norms for safety. In that respect, a university is arguably, at least as diverse as departments in other organizations. This diversity is significantly enhanced by the premium attached to it. Diversity of thought, freedom of mind and space are all considered essential ingredients of scientific innovation. When the management system was being sketched out initially, both the departmental and the EHS members stressed the importance of creating a flexible system. This would ensure the continuity of the freedom and diversity that are seen as essential to academic life. The system designers, including the EHS office and senior Welldon administrators, emphasized that the management system, and in particular the evaluation system, would accommodate the needs of each department – not all departments would be equally mature in establishing an improvement system, nor would all departments have similar hazards. The members of both the internal EHS office and the external EPA recognized the need for this flexibility. They emphasized that evaluating all departments similarly, without recognition of their needs or contexts, would defeat the original intent of the management system.

Several PIs too requested for flexibility because they considered their local spaces to be distinctive. One of them demanded that "[inspection] questions ought to be relevant to the expertise of researchers and the particular hazards they encounter." Linda, the lawyer, also agreed with this need for flexibility and emphasized it to the IT designers: "You need to make the PIs feel there are enough options that they can pick one that will work for them." The need for flexibility also seemed to be recognized by the EPA. One of the EHS managers claimed, "The EPA gave us so much time to create this system because they trust our judgment and our knowledge of how things work at the ground level."

With such a conviction that labs and departments were different, requiring their own local management, thoughts of comparability were rarely voiced in the initial days of database design. However, deeper understanding of the database features as well as better conceptions of other interests made people start focusing increasingly on the interest of comparability.

Discussions about comparability increasingly emerged as people became more aware of a need for 'fairness.' Notions of fairness are common in situations that warrant evaluation and consequences. The criteria of fairness, however, vary – both in distributive and procedural justice (Greenberg 1987; Leventhal 1976). Fairness could imply need-based consequences. Or it could require everyone to be treated equally regardless of need or context. At Welldon, the notion of fairness became more process and outcome-based as the design process continued and the fears of visibility and accountability increased, increasing the fears of being treated differently from someone else. So the concept of fairness shifted from being need-based to being based on equity. This notion of fairness was often invoked when requests for discretion were made and as people saw the discretion and flexibility actually being exercised in the form of differences in features and functionalities offered to different departments. In a meeting to discuss ways to evaluate inspection performance, one of the coordinators vocally objected to a proposal that coordinators should exercise discretion when rating violations observed in a lab.

Several coordinators had argued that contextual circumstances in a lab would make it difficult to objectively determine the severity of the violation. But such flexibility made some other coordinators like Tom uncomfortable who argued:

> It isn't fair that [one] coordinator cites something as one thing and another coordinator does it else how. That isn't acceptable! ....Some people have things on floor and others don't and I can say, if he can do it I can do that too.

The EHS office, too, felt uncomfortable about creating different requirements for different entities. One of the EHS managers stated:

> [I want to] avoid a situation where I create an exception for a place [such as Chemistry] that does a very good job. Because if some other department wants to do the same thing that Chemistry is doing, then we have to say 'no' to them. We have to explain to them why Chemistry can bend the rules. That's an awkward situation to put someone [in].

Another EHS manager, being disgruntled with all the requirements for flexibility, argued angrily:

> Well democracy is fine, but is safety negotiable? The same rules should apply for everyone. Safety is not negotiable.

PIs were not immune to this notion of fairness either. When the idea of localized inspections was still being considered, one of the PIs argued:

> Self-review leads to abuses...Regulation and inspection should have teeth.

This PI did not trust the departments to exercise the discretion responsibly and wanted a centralized body that could evaluate departments on standard criteria, and penalize them, if necessary.

The perception of equality was enhanced by the legal nature of the system. Law is said to be uniform in nature. This is especially so in the United States, where law is based on the principle of precedence. A judgment in one case would imply the same judgment in another, regardless of the specifics of the situation. The rationale for this is that discretionary judgments are expensive and would suffer from what Rawls calls the "burden of judgment" – that there inevitably will be diversity of values and reasonable disagreement among conscientious people (Rawls 2005, p.55). Equality in law is also desired because it creates predictability in judgment, and prevents illegitimate discrimination (Strauss, School, and Chicago 2002).

Despite assurances from the EPA that they respected Welldon's need for flexibility, members of the EHS office believed that the law would not recognize differences that existed in labs. This notion stemmed in part from this perception that the law treated everyone as equal, but also that anyone who wasn't intimately familiar with the idiosyncrasies of scientific research would have difficulty assessing differences in labs objectively.

Besides the emergence of this need for fairness, an increasing interest in efficiency also enhanced the interest of comparability. As the EHS office understood the enormity of effort that would be required to assess each lab and department at Welldon they started discussing ways to do this quickly, comparability becoming a means to achieve that. Comparing labs over time and across each other allowed the EHS office to assess a lab's performance quickly without getting into the detailed performance aspects of each and every lab.

Both the interest in efficiency and comparability also increased over time with increased standardization of data and centralization of management. Even though the initial assumption in the minds of people was to have greater local management, departments could not reach a consensus on what minimum standard should be established to satisfy the EPA. Things could not be completely laissez faire as in the days before the consent decree. Some standards had to be set to ensure that labs were adequately governed, beyond which the departments would have flexibility in how they wanted to customize their own training scheduling, local inspection practices, and accident management. The challenge to this belief arose when nobody could decide what this bare minimum was going to be. For example, some people argued that the bare minimum was two lab inspections a year while others thought that two was a very high number to conduct in a single year. The directives of the EPA, just like most laws, were fairly ambiguous and open to interpretation. During arguments such as the one on the frequency of inspection, people turned to members of the EHS office to ask what the EPA had asked for, but the managers at the EHS office rarely had a clear response: "We don't have to have all the information… the EPA didn't specify exactly, we have discretion."

As standards became increasingly difficult to establish across labs, the EHS office started shifting towards greater centralization. Such centralization would take the decision making out of the hands of the departments who could not be trusted to maintain the standards that were ostensibly required to satisfy the EPA. Centralized standards were also accompanied by centralized records to be maintained by the EHS office. Ron, one of the PIs argued that the inspection records for each lab should be maintained locally in the lab and if the EPA or the EHS wished to access them, they could ask labs for these records. But Linda, the lawyer, argued back that it was not "administratively feasible" for the EHS to visit every lab to check whether they were following the rules of inspection. Stan, an EHS manager, appealed to the faculty that the EHS office should be directly involved in all lab inspections:

> Excluding EHS from inspections doesn't make for good EHS professionalism. My professional development has been through interacting with faculty, I caution you not to exclude EHS, I don't want to be called in only on emergencies and problems.

Centralized decision making and standardized record keeping enhanced the interest in comparability. A single entity such as the EHS office could not easily evaluate each lab and department on local criteria. It needed certain comparable standards to assess how the labs had been doing – both over time and compared to each other. Moreover the centralized management also increased the burden of assessment for the EHS office. Again, comparable and standard assessment criteria would ease the data analysis burden for them.

Finally, the interest in comparability also emerged as the EHS office got increasingly vocal about creating a system that would enable labs to go "beyond compliance." If capturing compliance was the only objective of this system, the evaluators could create a binary rating of 'compliant' or 'non-compliant,' allocating the appropriate rating to each lab, based on certain guidelines. But the EHS Office's desire to create a more complex evaluation system meant that not only would labs attempt to be compliant, but they would also seek constant improvement, thus changing the focus of the management system from assessing compliance, to assessing improvement. This had repercussions on how evaluations would be performed, since improvement could only be assessed through the *changes* that the lab had undergone in its EHS processes.

How does one assess change? One way to do so would be to *compare* a lab's performance *over time*. This, however, would require a consistent set of parameters for a lab across the time periods so that comparison would be possible over time.

Another way to assess change would be to establish some benchmarks that the labs would then emulate. At Welldon, for instance, the EHS office often used the example of the Chemistry department to illustrate a model process for creating compliance, and for identifying those falling short. In that case assessing improvement for a lab would be based on how far a lab was from achieving the established benchmark. But benchmarks themselves could only be established and used if departments were to be compared on some set of consistent information. Every department would need to be evaluated on the same parameters that were being used by Chemistry, or Chemistry would need to be evaluated on the same parameters that were being used by the other departments.

In this way, several factors like fairness, efficiency, standardization, and a desire to assess change, contributed to the emergence of comparability as an interest. The emergent interest itself subsequently led to requests for features that could accommodate comparability.

Desire for comparability

Comparability could be achieved in two ways: (1) by making EHS *processes* comparable across labs and departments, (2) by making *outcome variables* comparable across labs and departments and within labs, but overtime. The comparability across the departmental entities would then also satisfy users' notions of fairness – that both the processes as well as the measures of evaluation were the same for different arms of research at Welldon.

Fields, features, and functionalities that allowed such comparability became much more popular with the emergence of this interest. Functionalities like automatic reminder notifications on missed training or impeding inspection had to be common for all labs. Similarly the number of annual inspections as well as the actual list of inspection questions had to be the same for every lab. Tom, a coordinator, advocated a standardized checklist of questions for all departments. When several departments asked for their own versions of questions, Tom asked: "How do you compare if everyone is doing it their own way?"

In terms of outcome fairness, the interest in comparability led to a desire for metrics and scores that would enable a quick comparison across labs or over time to see how that particular lab had been doing with respect to itself in the past or with respect to other labs. As seen in Figure 7, the IT designers included an overall score on a scale of 1 to 5 in the inspection form. The inspectors were asked to score each lab on this scale at the end of the inspection. Stan in the EHS office argued in favor of such a score:

> We can't read statements from 2,000 labs...If one group routinely gets 3s [points], while others get 4s and 5s...this [classification] is to give a quick trend report. (EHS Manager, 2002)

Stan believed that such a score would enable the EHS office to differentiate between the routine laggards getting low scores from the high performers at Welldon.

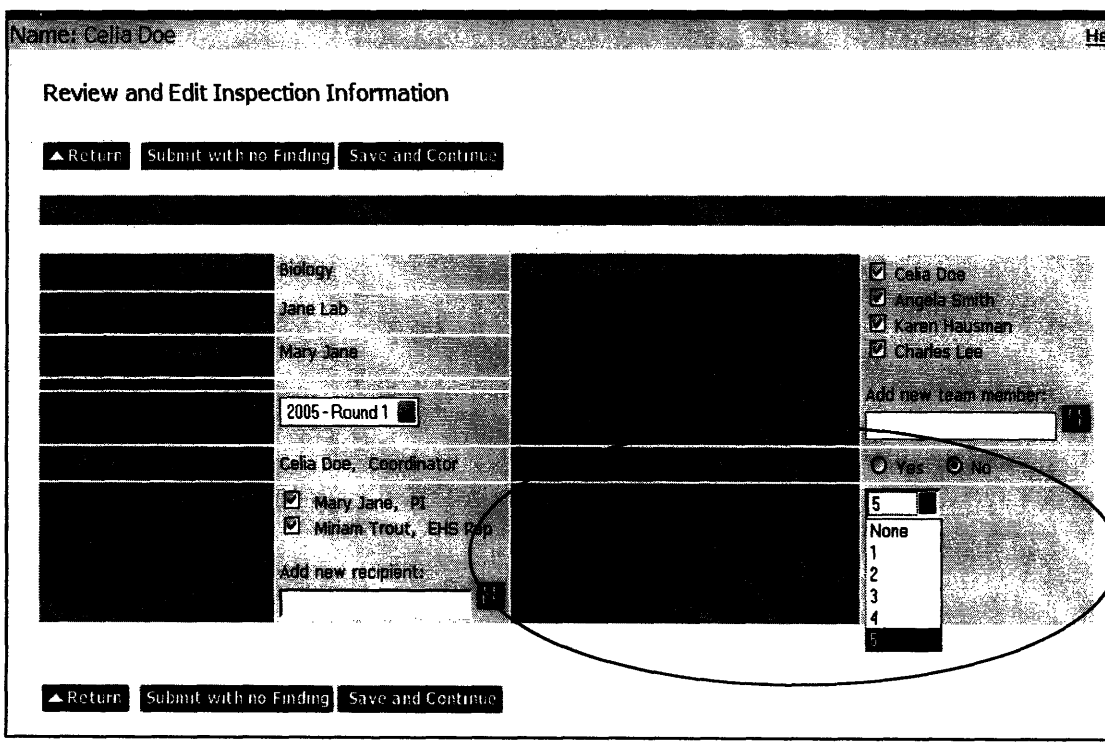


Figure 7: Creating a Comparable Inspection Score for Labs

Trends also fulfilled the desire for comparability. Users wanted to be able to see how the labs had been performing over time. A count of reported non-compliances over time would be used by the EHS office to assess the change in that number over time. Dan, the consultant, explained:

> [The EHS office will] look at [percentage] of non-compliances and if that number doesn't go down, they'll have concerns. It should go down over time.

The quest for trends was not just restricted to those in the EHS office, who on the surface seemed most concerned about observing and demonstrating improvements in labs over time. Even some coordinators were bitten by the trend bug. They wanted to use these trends to evaluate progress in their own departments. Meela in Biology argued for 'trendable' data in several conversations, even when creating this possibility meant additional technical effort. In a discussion of what counted as a single non-compliance versus multiple non-compliances, Charlotte, a coordinator in Facilities asked whether every chemical bottle in a lab that was found uncapped would be counted as one non-compliance.

> [IT consultant]: Let's say caps off. Are you going to say caps off, caps off..[and report each one of them separately?]
> Charlotte: No..I wont
> Meela: You might if you talk about SAA.[24] SAA on bench, SAA on somewhere else
> [IT designer]: So will you have a different [non-compliance reported] for each one of them?
> [IT consultant]: Question is how complicated do you want to make it? Do you want to make this on exception [and not have the technical design changed for your request]?
> Meela interrupts: That's not an exception
> [IT designer 2]: It is not a question of exception but are you okay [reporting it as one non-compliance and describing the severity] in [text-based] notes?
> Meela: But you won't be able to trend it

---

[24] SAA or Satellite Accumulation Areas are regulated areas in labs earmarked for waste storage. Since the waste in these areas is of a hazardous nature and requires special disposal arrangements, it is highly regulated.

Meela wanted the ability to list every non-compliance separately so that these non-compliances could then be counted for data analysis. Even when this sounded technically, and practically infeasible, as in the case of non-compliances related to uncapped chemical bottles, she was worried that having this listed as just one non-compliance would not allow for the severity of this to be recorded and analyzed. Even when this severity could be recorded through a text box – which would, for instance, say that 2000 bottles were found uncapped – Meela felt that text boxes would not allow for trend analysis. For coordinators, such as Meela, who came from departments that were definitely more aware of regulatory requirements and were doing their utmost to comply, trends showcased their efforts. Desire for comparability further created a desire for consistent and standardized features that would then facilitate the creation of metrics and trends.

Desire for consistency and standardization

Standardization has been a big organizational force for at least the last two decades. Standardizing business processes is said to provide many organizational benefits in terms of lower overhead costs, and single to customers and suppliers (Hammer and Stanton 1999). Standardization of business processes has further translated into a desire for standardized data for organizations, since it is difficult to have a standard process if data and indicators differ across business units. As a result, several methodologies for data integration, including relational data forms, have been developed that facilitate the creation of standardized and consistent data (Goodhue, Wybo, and Kirsch 1992).

Despite the push for standardization in other organizations, and despite the use of an Enterprise System package for human resources, payroll, and accounting, Welldon administrators emphasized diversity and creativity in scientific research. The existing ES package somewhat constrained this creativity but it did not significantly interfere with research-related practices in the lab. There was an understanding that certain degree of standardization would be there but it would never overshadow the need for a flexible system. However, with the emergence of the desire for comparability, consistency and standardization became important even at Welldon.

In order to have comparable processes and outcome variables, the IT designers needed to include features that would be enable such comparability. This led to an enhanced use of drop-down menus without which one could not easily have the metrics like the overall lab scores. On the other hand, one could count the number of "major" violations discovered in a lab, count the number of consequences, and then determine the overall score for the lab.

Comparability in EHS processes also meant a definition of consistent processes that could then be incorporated into the database system. This way, for instance, one could say whether a department had failed to do its mandatory two inspections a year that every department was supposed to do. Even when concerns about such consistency were raised, and exceptions requested, people wanted consistency in defining such exceptions. For example, when some of the coordinators raised the possibility of not being able to complete the inspections in time, the following debate ensued as to what the circumstances would be to warrant an exemption on an overdue lab inspection.

> Ray (coordinator) then shows the form for permission to abstain from an inspection. He passes the draft letter he has prepared. People debate about different words in the letter. He has written "director of environmental programs" for approval granting authority. Michael in the EHS office asks who that authority would be. They debate about whose signatures are required. Should the letter say "Departmental chair?" Corey in the EHS office mentions that the department of facilities doesn't really have a departmental chair. Ray thinks that the Departmental chair should not sign the form. Lucy thinks that departmental chair is not "high enough." She thinks it should be dean. George, the EHS manager says that the situation should be serious enough. Lucy provides an example of a lab move that makes inspection difficult to do. There is more discussion on what a reasonable enough extension would be for a move. Lucy asks what the drivers would be. Is the driver for an extension on

> an inspection not getting the data into system? Or is it not getting physical access to lab? George suggests that it has to be an inability to have physical access to the lab, such as a virus, fire, flood. Corey then says: "Jeff: can I suggest that we do not codify what the situation is and use professional judgment." To this Lucy says: "we have to specify the procedure even if it is with a broad brush." (Field notes, October 6, 2005)

The need for comparability across labs was so high towards the later stages of design that even when external circumstances made it difficult to have comparability across the typical process, one needed to consistently define what these exceptional circumstances were so that some semblance of comparability still remained across labs. In the exchange above, people recognized the difficulty of consistently defining exceptions. After all, a lab could get delayed in its mandatory inspections for several reasons, such as a move, a fire, or other such catastrophes. It wasn't possible to foresee or define every such exception, since not all of these exceptions would warrant an exemption on inspection; some could just require an extension, while others could require alternative actions. Despite the frustration encountered in defining these exceptions, it was felt by the EHS office that some protocol for exceptions had to be adopted. The protocol would shape the sequence of actions in assessing whether a lab could be granted an extension or an exemption on its inspection. The protocol itself would need to be largely pre-established and applicable in a variety of circumstances and settings.

The desire for consistency was also magnified because of other factors such as the need for efficiency as well as the technological constraints of the ES package. Automation was a functionality introduced to promote faster data entry. Automation, however, requires that the system has a pre-established and consistent set of events that could be generated in response to the preceding events, regardless of the contextual situation. So, for instance, every time a lab was delayed on its inspection, a warning letter would be sent to the PI, with a copy to the departmental head. Once this sequence of events got hardwired into the technological system, a warning letter would be *consistently* dispatched to the PI, regardless of the specifics of the situation.

Efficient data-entry through 'automation' created this need for consistent actions. Efficient data *consumption* also required consistency of information that was extracted out of the database. Processing very diverse information would make it difficult for the consumers, mainly those in the EHS office, to make sense of the information very quickly. Consistent responses would make consumption of data easier. As Maureen, an EHS officer noted: "If I ask 35 PIs 'what do you want to do?', we will get 35 different answers; we don't want to have all that work. I want consistency to minimize the work."

Finally, the database technology itself was a big driver in the desire for consistency. While an oral rendition of an incident is capable of reflecting many flavors, the written form imposes several constraints on what format should be adopted. There are certain implicitly or explicitly defined genres in written communication that people mostly enact. These genres, such as memo or business letter are not pre-determined, emerging instead through practices over time, but they nevertheless reflect certain forms and purposes that constrain and enable those who use them (Orlikowski and Yates 1994). Technology has the potential to further enhance these constraints and enablements.

At a minimum, database technology imposes the use of standard labels and formats. For instance, even in the written inspection form at Welldon, some sort of consistency was essential because the information from the written forms was electronically scanned so that the information could be maintained as electronic images, instead of being retained in the paper form. This electronic scanning created a need for certain standards in the paper-form because the scanning software was not able to recognize too much diversity in formats and templates, at least not without significant effort on the past of these scanning the information.

Often, though, technology made entire fields of information invisible or visible for the sake of consistency. For instance, when the questions for the lab inspections were being evaluated, several departments had their own versions of inspection questions that they wanted included in the question checklist. These unique questions stemmed from historical practices, as well as specific hazards that were unique to a setting. Yet, it was not technologically feasible to have a unique question bank for every department. The IT team often lamented the lack of standardization and how difficult their tasks became with this much diversity. Andy, a temporary ES consultant at Welldon, was shocked at the flexibility that the IT designers were building into the system. He urged the team to have greater consistency:

> As long as I can, I [will] fight, 'hey! lets keep this standard.' In the long run it is cheaper. In universities you have very smart people with sophisticated web applications. But [the] more you do client specific [customizations], more expensive it is.

The IT designers thus urged users towards greater standardization as well. They asked departmental coordinators to pool their questions in a way that allowed for one standard list of questions that every department had to then draw on to conduct their own very diverse inspections. This effort at standardization and consistency led many departments to feel aggrieved that their styles and contexts were not being accommodated through the web-based inspection checklist.

Interestingly, this technology-imposed consistency was also a little more acceptable to most people than the consistency imposed by human beings. At a place like Welldon, with its informal hierarchy and deference for faculty, technology was seen as more impartial, invisible, and apolitical, and often used as a shield by administrative staff. Many of them felt uncomfortable about being rigid in their expression of rules even to their peers, and definitely to faculty. They believed that people would perhaps not accept a rule imposed by another human being, but they would be more inclined to accept consistency as a constraint when it was embedded in a technological system. The staff could simply shrug and say that they did not create the rules but, rather, "it is the system [that is inflexible]."

Several designers of the EHS database system leveraged this belief when it came to getting faculty to accept certain rules. For instance, the coordinator in Bioengineering was concerned that the faculty in his area were not completing their training. Some of the faculty in Bioengineering felt that their department needed time to get up to speed on training and would therefore require an extension on training deadlines. This coordinator urged the system designers to create checks in the technological system so that the faculty in every department could be sent reminders for missed training. He felt that system-generated automatic reminders would be much more effective in getting the faculty to display behavior consistent with other faculty than confronting them directly with this demand. He believed that having the system enforce consistency would be more acceptable than having the EHS officers or the coordinators require it.

Of course, as the desire for comparability and consistency proliferated, and features were incorporated to standardize the processes and information in the database, people began having concerns that they were being 'boxed-into' a rigid system that would erode their context-specific concerns. They started expressing these fears of misinterpretation and lost flexibility.

Fear of misinterpretation

The drive for consistent data worried several people at Welldon. They felt that information was being twisted to fit into the database system and did not depict them as individuals, or departments, accurately. They often complained that this was a "one-size-fits-all" system, where everyone was asked to do things similarly and if there was a chance of disparity in how things were reported, then that disparity had to be addressed, often by omitting some information altogether, as seen in the case of 'best practices.'

While information about lab non-compliances was mandatory and "required" to be entered into the database system, information about best practices was optional. Not everyone had best practices to report, and even if they did, they did not *have* to report them. The system, after all, was geared towards first catching non-compliances, and then towards improving lab practices. While this did not prevent the database designers from creating a separate field to capture best practices, they chose not to do so. One rationale, already mentioned in a previous chapter, was that this would make the system bulky. Another reason for this resistance was imposed by technological demands of consistency. The designers of the database system feared that making some fields mandatory, while others optional, would dilute the importance of the former. As one of the EHS managers noted: "The problem is with the database mixing people who we want in there [as examples of good practice] versus people required to be in there [because of non-compliances]. [I am concerned] that people will think things are optional… [It] could get confusing."

As a result of this desire for a consistent-looking database,[25] the designers decided to remove the field to separately capture best practices. Instead, they decided that if someone had some best practices to report, they could use the fields for non-compliances to do so.

Such attempts to achieve consistency then produced fears of misinterpretation. In this case of best practices, several coordinators worried that their reports on best practices would be misconstrued as non-compliances and would reflect badly on them. Josh, a coordinator lamented in one of the meetings:

> We have a lot of entries for questions that aren't necessarily compliance [non-compliances], but best practices. Some people who saw our report said , wow, look at all these [non-compliances]. My concern is that those observations would be viewed as negative; higher number of [non-compliances] would be Oh Oh! That indicates bad. Pressure would be to reduce the number of [non-compliances] to look good.... Folks at [senior] level will only ask for report -- tell me how many [non-compliances].

Coordinators like Josh feared that they would be penalized for their commitment to contribute to the system. Why would they then report any best practices, and spend additional time to generate some data, if there was a possibility that their zealousness would be misconstrued, instead of being rewarded? Consistent with this fear, I have noticed that in the reports that the inspection form is generating now, information about best practices almost no longer exists. Coordinators have stopped spending time reporting best practices.

Discussions about trends too generated anxieties. Several coordinators and departmental administrators feared that the data underlying the trends would not adequately represent their situations. People did not quite understand how to classify a non-compliance and they did not have enough experience to understand what was really a

---

[25] The field for best practices was removed both to preserve consistency and efficiency.

serious violation and what was relatively minor. In such cases, trends would hardly be meaningful. One of the coordinators voiced these concerns:

> We are supposed to do trend analysis when we have just started doing inspection. Is it possible to defer this trend analysis till we have a steady data [and] have had time to work on things?

One feature that the designers constantly went back and forth on was that of scores. While the overall scores for a lab enabled comparison in labs, they also led to concerns about losing contextual details on the individual non-compliances. As a result of these concerns, the IT designers decided to remove the field for overall inspection score seen in Figure 7. Instead they decided to include a field to rate every individual non-compliance. So the inspector conducting the inspection would now observe any violations, assess the severity of the situation, and then rate the violation. The form for inspections changed to include this discretion, as seen in Figure 8.

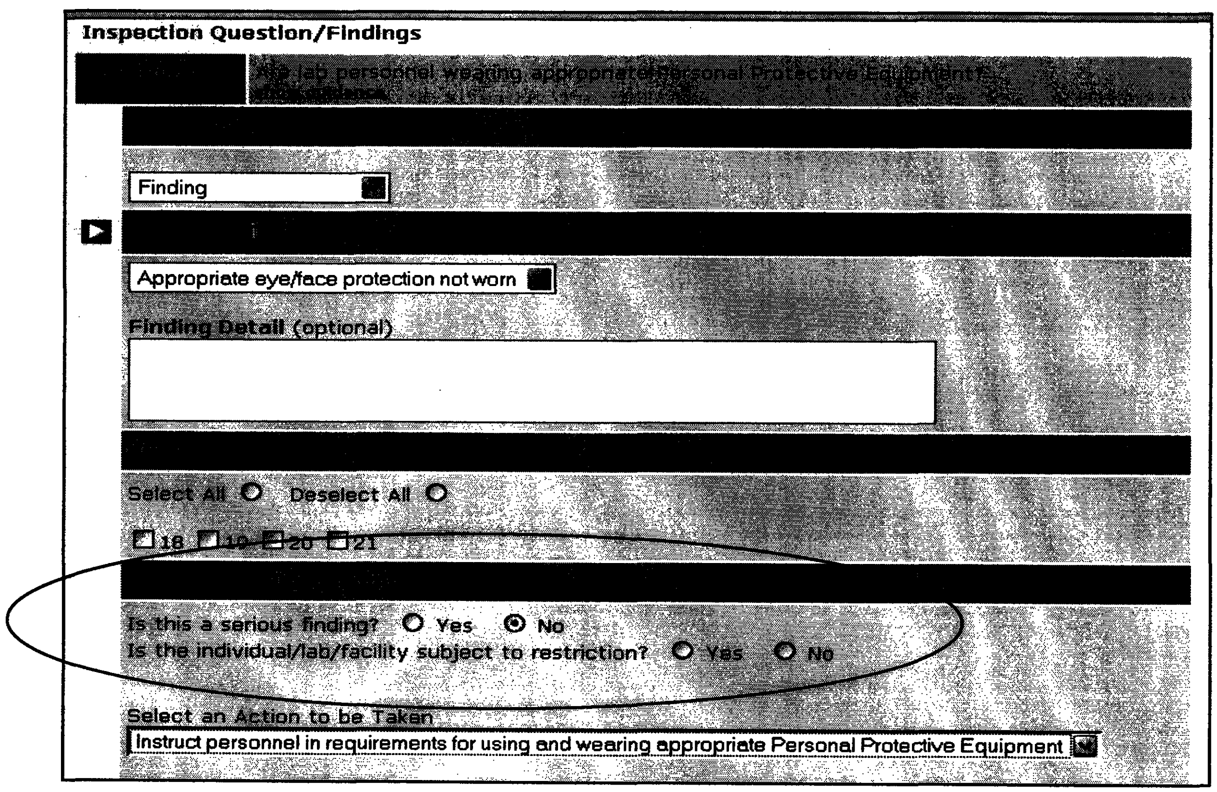


Figure 8: Using Discretion to rate Non-compliance

As seen in the example in Figure 8, if an inspector found that researchers were not complying with the requirements for protective equipment, they would consider the situation carefully. They would ask about the kind of experiment being conducted and whether the nature of the research made the absence of the protective eyewear potentially catastrophic or relatively minor. The decision to have such discretion in classifying violations was not met favorably either. As seen in the sections above, coordinators got uncomfortable about the absence of fairness when they felt that two labs could be citing the same violation very differently. This example of overall and discretionary scores highlighted the constant tussle between fairness, comparability, and misinterpretation.

Fears of misinterpretation caused significant changes in the system. But it was the fear of lost flexibility that created most resistance, especially among faculty and also among coordinators, given how cherished flexibility was in the academic community at large at Welldon.

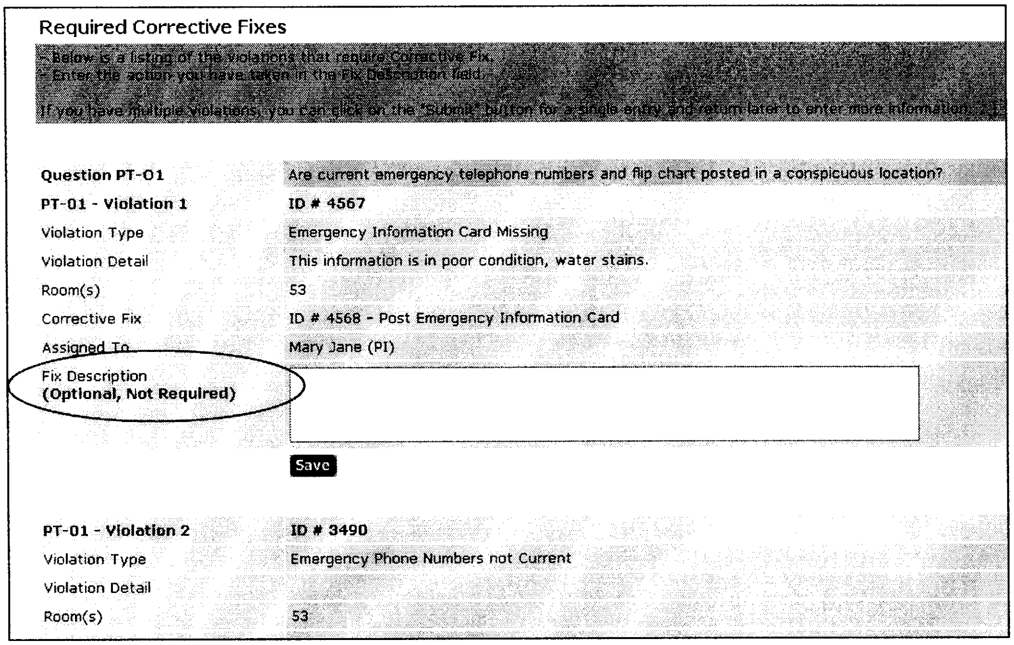
Fear of lost flexibility

As consistency was enhanced, flexibility got diminished. Several coordinators in departments that were relatively new to the inspection system wanted their faculty to create a written record every time they fixed a non-compliance. This desire was due to the newness of the system in these departments, and the lower trust among coordinators that the faculty would take care of any non-compliances that were found during inspections. Yet, there were other coordinators in more mature departments who did not want any written accounts for fixes. Al in the School of Science argued "The cultures are different -- you tell [the faculty in Chemistry that a practice] needs to be fixed and they do it.... designing to the lowest common denominator is restrictive and bureaucratic." Meela in

Biology feared that "bureaucracy takes away from your real job. I don't want us to over engineer this."

Despite this fear of reduced flexibility, the EHS office wanted all departments to keep these accounts. Linda, the lawyer argued, "we ran into a situation with EPA because they found some records but not all areas kept them. Once you have some information, but you don't have it someplace else, that can be held against you."

When coordinators continued to resist this "one-size-fits-all" policy, the EHS office was compelled to accommodate some flexibility. The recourse was to adopt an option called "not required." This meant that certain fields, such as a field to enable people to provide accounts for fixes, would be provided to meet the needs of certain coordinators. However, the field would have a specific label preceding it "Optional, not required" (Figure 9). This was to prevent any liability against Welldon for missing information. If certain people left that field blank, they left it that way because the information was optional anyway. Of course this meant that eventually most people started leaving the field blank; whenever something is deemed optional, parsimony tends to triumph.


Required Corrective Fixes

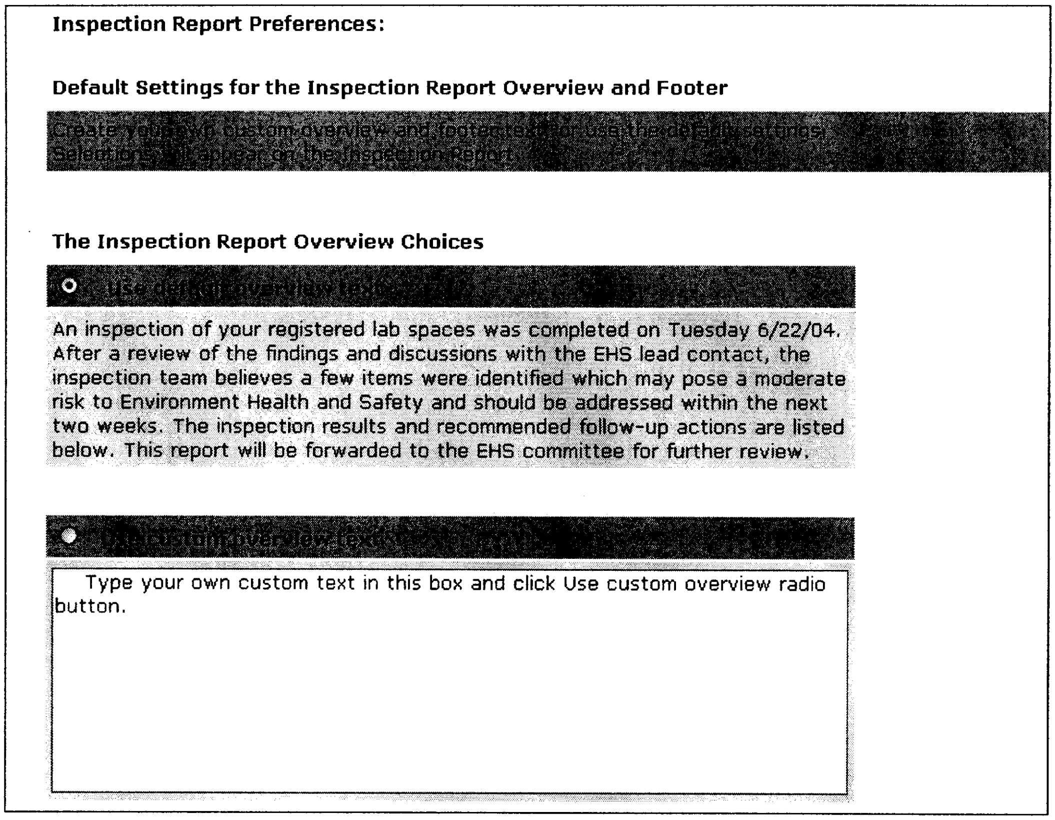
- Below is a listing of the violations that require Corrective Fix.
- Enter the action you have taken in the Fix Description field.

If you have multiple violations, you can click on the "Submit" button for a single entry and return later to enter more information.

Question PT-01	Are current emergency telephone numbers and flip chart posted in a conspicuous location?
PT-01 - Violation 1	**ID # 4567**
Violation Type	Emergency Information Card Missing
Violation Detail	This information is in poor condition, water stains.
Room(s)	53
Corrective Fix	ID # 4568 - Post Emergency Information Card
Assigned To	Mary Jane (PI)
Fix Description **(Optional, Not Required)**	
	Save
PT-01 - Violation 2	**ID # 3490**
Violation Type	Emergency Phone Numbers not Current
Violation Detail	
Room(s)	53

Figure 9: Providing some Flexibility with Optional Fields

IT designers proposed more creative and comprehensive solutions to accommodate flexibility, such as adding an introductory screen where every department could specify its own preferences and somewhat tailor its forms to reflect its contextual requirements. For instance, as shown in Figure 10, departmental coordinators could choose to have their own textual content when they were reporting the inspection results to the lab PIs. The designers gave this option to the coordinators after some of them objected to having a standard text that would be sent to PIs after the conclusion of an inspection. They felt that the specifics of an inspection, and the relationship that they shared with their PIs, required them to use a more customized language. Customizations invariably added more design complexity and therefore were limited in use. Often design continued to be "simple and consistent."



Inspection Report Preferences:

Default Settings for the Inspection Report Overview and Footer

Create your own custom overview and footer text or use the default settings. Selections will appear on the Inspection Report.

The Inspection Report Overview Choices

Use default overview text

An inspection of your registered lab spaces was completed on Tuesday 6/22/04. After a review of the findings and discussions with the EHS lead contact, the inspection team believes a few items were identified which may pose a moderate risk to Environment Health and Safety and should be addressed within the next two weeks. The inspection results and recommended follow-up actions are listed below. This report will be forwarded to the EHS committee for further review.

Use custom overview text

Type your own custom text in this box and click Use custom overview radio button.

Figure 10: Form to allow some Customization of Reporting

Summary

As seen in Table 5 and Figure 11, the emergent interest in comparability led to several changes in the database system that created comparable processes for evaluation, as well as comparable outcomes. Such comparable aspects in the database, however, led to desires for consistency and standardization since it was difficult to observe comparability across outcomes and processes without some standardized fields and consistent parameters. These standard fields enabled the generation of comparable information, which was useful both by itself, and in producing metrics. However, comparability and standardization came at a cost, creating both fears of misinterpretation and fears of lost flexibility. To counter the former, several text boxes were included that allowed the addition of contextual details. To counter the fears of lost flexibility, the IT designers had to include complex options that enabled customizations but were difficult to create in a technical system.

Desire/Fear	Who/whom	Fields/features/functionalities
– Desire for comparability	– EHS office – Coordinators – Faculty	– Metrics – Trends – Comparable processes
– Desire for consistency and standardization	– EHS office – IS Designers – Coordinators (through desire for efficiency)	– Standard and quantifiable fields across departments – Consistent processes
– Fear of misinterpretation	– Coordinators	– Omission of fields – Inclusion of contextual details
– Fear of lost flexibility	– Coordinators – Faculty	– Inclusion of complex options/customizations

Table 5: Actors, Fears, Desires, and Functionalities stemming from the Interest of Comparability

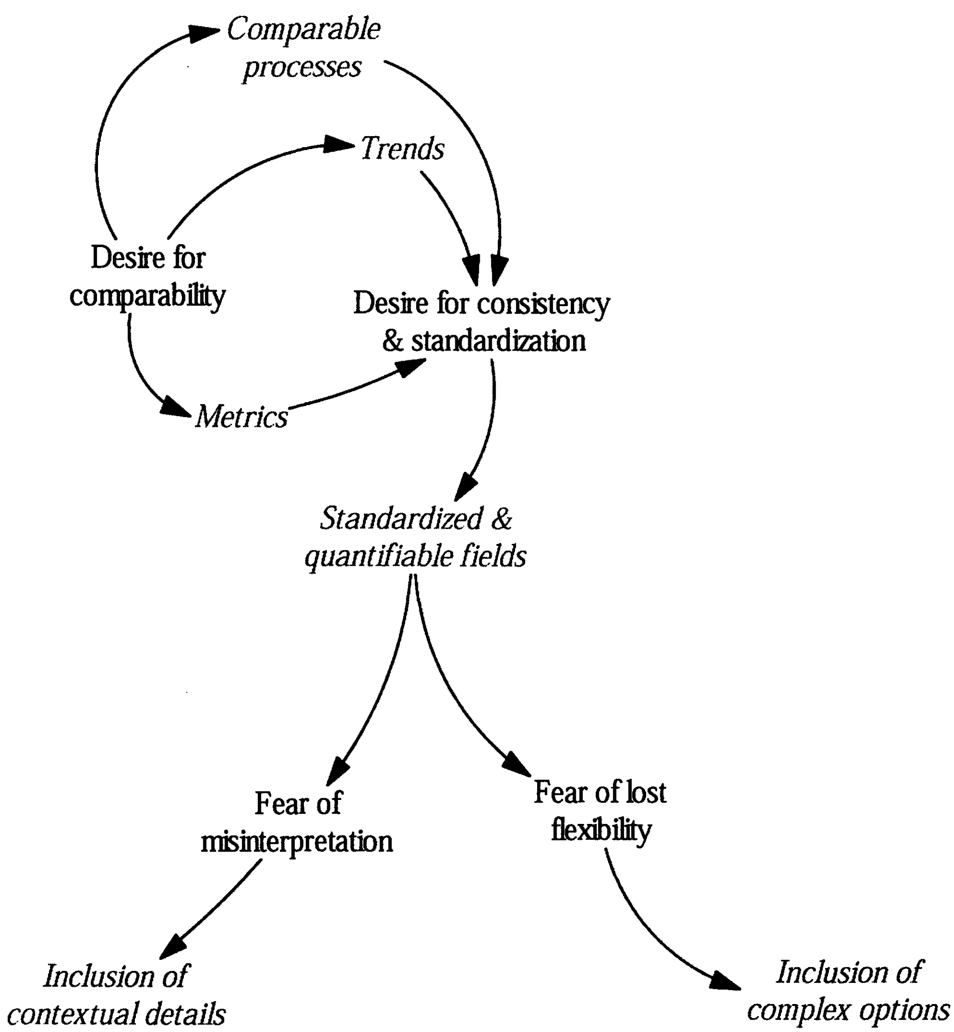


Figure 11: Fears, Desires, and Functionalities stemming from the Interest of Comparability

VI: The Contradictory and Dynamic Design Process

The discussion so far offers some insights into the complexity of the database design process. The interests, fears, and desires highlighted provide some explanation for why systems depart from their original intent and strategies. The fears and desires that are experienced by the users and designers of the system are often unanticipated when the original goals of the system are determined. It is only with the increased articulation of the system intricacies that the fears and desires get triggered. In this chapter I want to delve into an aspect of the design process that was implicitly present in the previous chapters – contradictions.

The system design process would be relatively straightforward and remain focused on its original goals if everyone were to converge towards the same goals at all times of the design process, regardless of the fears and desires. However, this is clearly not the case. Complexities arise because people contradict others' *and* their own interests. These contradictions are made visible through the features and the functionalities of the database system and compel multiple iterative modifications to these features and functionalities. Ironically, these iterations often only exacerbate the contradictions.

I next discuss some of the key contradictions that were seen in the design process at Welldon and how the designers attempted to resolve them. I then discuss the complexities that these attempts often entailed and the implications of the contradictions for the goals of the database system.

The Contradictions

Several scholars have criticized the tendency in the organizational literature to generate consistent theories (Poole and van de Ven 1989; Robey and Boudreau 1999). Organizations are almost never single-faceted. They have embedded contradictions such as stability as well as change. Robey et al. (1999) highlight several such forces in organizational literature with respect to the use of information technology – in politics, culture, institutional theory, and in organizational learning. The contradictions could be due to role conflicts among individuals, or due to changing value perceptions over time (Cameron 1986; Markus, Axline, Petrie, and Tanis 2000). An emphasis on contradictions and paradoxes allows a more nuanced understanding of phenomena. It also helps us deal with diverse outcomes associated with similar triggers .

At Welldon, the complexity in design was a result of several contradictions that were not apparent at the outset. These contradictions arose primarily because of distinct positional goals that did not always converge, or because of interests that clashed. I discuss these two kinds of contradictions next.

Positional interest-based contradictions

Most literature – especially on power, and politics (Bloomfield and Coombs 1990; Sia, Tang, Soh, and Boh 2002) -- postulates that social and organizational conflicts occur because of differences in power across actors. Organizational changes often enhance this conflict because of their potential to shift the existing power relations.

It is difficult to clearly map the power relations at Welldon. Regulators wanted to control Welldon administrators and researchers, EHS staff wanted to control coordinators and researchers, and coordinators wanted to control the researchers. It would seem that researchers were at the bottom of this control chain, everyone ultimately wanting to control their actions. Moreover, given the mandates of the consent decree, this control seemed highly legitimate. After all, without proper accountability on the part of researchers, they as well as the rest of Welldon would be in trouble. Yet, in terms of the power equation outside of the EHS practices, researchers moved from being at the bottom of the control chain to being at the top. As I have mentioned, researchers, especially faculty, were highly regarded by members of the EHS office as well as by the coordinators – who occupied administrative roles in the very departments that housed these faculty researchers. On the other hand, coordinators grew quite powerful themselves, while still deferring to the faculty researchers, but exercising considerable collusive power with respect to the EHS staff.

Control and resistance are almost inevitable elements of organizational routines even when the power equation is highly unbalanced. At Welldon, because of the crisscrossing power relations, the dynamics of control and resistance generated contradictions that were difficult for the system designers to manage.

In terms of the database system, the EHS office wanted information about the coordinators and the researchers; the coordinators wanted information about the researchers. And yet, the coordinators were reluctant to provide information about themselves or their departments to the EHS office. Coordinators wanted information about the researchers, but researchers did not care to spend the time or the effort that such information collection demanded of them.

This desire for information and the resistance to making it available led to some of the debates seen in the previous chapters. Such debates were especially evident in the case of authorizations where the EHS office wanted authorizations to view departmental information, but the coordinators and faculty members were concerned about letting the EHS office access to what they thought was their own dirty laundry.

For instance, typically an investigation had to follow a major accident or injury occurring at a Welldon lab. The investigation had to be conducted jointly by a committee of lab members and the EHS staff members. Given that the members of the investigation team would all be aware of the results of the investigation, the IT designers suggested that the EHS staff be authorized to enter these results into the system. At this, a coordinator objected and asked: "[what if] someone [from the department] objects to the investigation or results of the investigation?"

Sarah, the coordinator, also wanted the departments to be authorized to edit any investigation results. Dan, the IT designer, argued that the database system was only going to be a formal placeholder to describe the results:

> This [database] isn't the process for doing investigation. This is not to replace an investigation that happens offline. This is just a place to record things.

Dan argued that consensus and conflicts needed to occur and be resolved outside of the database system and the database system would only be used to store the results of the investigation after it had been finalized. Yet, Sarah was not satisfied. She felt very threatened about giving the EHS office the exclusive rights to enter and edit the investigation results. As a result, the IT designers had to change the authorization rights and create a more complex system where authorization rights now had to be defined before every investigation.

Similar debates were seen with respect to metrics. Some coordinators were very concerned about letting the EHS office view the lab inspection scores. In this case, however, legal mandates enabled the EHS office to continue to have the authorization to view the lab scores. Since the EHS office was the face of Welldon to the regulators, they had to be aware of the problem labs and therefore needed to know their scores too.

These contradictions across stakeholders where one group desires control over another, while the other resists, is one reason for systems departing from their original goals. It is difficult to reach a consensus that meets everyone's approval, and the systems designers need to make compromises to keep different sides engaged.

In systems that involve few people during design, contradictions often only become evident once the system has been deployed. As people understand the control that others can exert over them through use of a system, they often devise ways to shield themselves (Cunha 2006; Zuboff 1988). Indeed, Thompson and Smith argue that "there is consistent confusion between technological potential for surveillance and the managerial capacity to monitor and manipulate, and between managerial discourses about correct behavior and the reality of continued misbehavior" (2001, p.55). Cunha (2006), in his work on salespeople, shows how they manipulated the software that was being used to track their sales performance. These salespeople, by performing some tasks for the customers, put their names on even those sales that they had not been directly involved in, thus raising their sales figures, and being awarded large bonuses. Similarly, Bain and Taylor (2000) discuss the strong control mechanisms in place in one call center, including direct manager supervision, computer logs, and remote observations by supervisors. Yet, employees found individual and collective means to resist some of these controls. For example, one way to monitor employees in the call center was to measure their idle time, which led employees to not relinquish their calls even after the customer had hung up, thus reducing their logged idle time.

In highly participatory systems, contradictions, especially around control and resistance, surface earlier in the system lifecycle. Robey and Farrow (1982) argue that conflicts, although not always dysfunctional, are higher in participatory design where users get more familiar with the system's implications for them. As I show later, this may be a double-edged sword. Contradictions surfaced earlier on may prevent some future pitfalls, but an over-zealous appeasement process may generate important disadvantages.

Control and resistance clearly cause tensions in the database design and ultimately may lead to shifts from the original intent. Database design becomes yet more complex because of the multiple interests around the system.

Other interest-based contradictions

Modern database and software systems try to encompass multiple goals as well as multiple interests. Getting databases to demonstrate accountability both efficiently and consistently leads to other contradictions. Desires from the perspective of one interest become fears from the perspective of another.

A desire for evaluation meant inclusion of a lot of information in the database system. The information could be of many different kinds, and could take many different forms. Yet, with every attempt to include extra information came the fear of overburdening the data providers and data consumers. As the EHS office, for instance, wanted information about consequences in a department, departments feared that the form would be made yet more cumbersome in order to incorporate a field that reflected an exceptional event.

In other cases, departmental coordinators feared that they would be evaluated unfairly and wanted the form to allow more information. For instance, Meela wanted to be able to elaborate on non-compliances found in her labs. If her lab did not have correct signs posted, she wanted the ability to say whether the signs for radiation were missing or more minor signs were missing. She feared that the EHS office would unfairly judge her for a missing sign, when the context made the observation much more minor. The IT designers counter-argued that trying to incorporate every contextual detail into the database system would make the design too bulky.

Desires for consistency also ran up against desires for more information. Coordinators wanted the ability to report good practices in their labs because they wanted to showcase their efforts. Yet, the EHS office feared that the optional fields to report the good practices would make the field for non-compliances also appear optional. They wanted the database to appear sufficiently consistent in the response required by the coordinators.

The contradictions discussed here would not be so sharp if people did not imagine so many interests being fulfilled by the database system. If coordinators did not imagine that the database would be used to evaluate them, they would not object to maintaining information about the missing signs in the most efficient manner. But fears of evaluation crossed purposes with the desires for efficiency. Indeed this is reflective of most systems that are typically designed with several interests and goals in mind.

The contradictions described above would make the reader believe that contradictions are a result of multiplicity of roles. Multiple roles lead to positional interest-based contradictions across people. This assumption would be correct but only partially so because contradictions do not necessarily need to involve multiple roles or actors. Even the same individual may be found to have contradictory desires and fears. These contradictions become more pronounced as individuals gain a better understanding of the artifact and its uses.

Over time, as the database became more concrete and well-defined, several people started contradicting not just others but also themselves. For example, the coordinators wanted to resist entering information about consequences because it would involve significant effort, and yet the same coordinators also wanted to expend additional effort to elaborate their non-compliances because a simple drop-down menu risked the possibility of misinterpretation by the EHS office.

The contradictions became increasingly dramatic when I saw the same individual making completely opposite demands for the same piece of information. Earlier in the design process when the EHS staff proposed having automatic classification for some non-compliances, Natasha objected:

> "I don't want to bump up [broken] eyewash [stations] and unlabelled bottles [to a rating of "major"] just because it is a repeat [non-compliance] because [these non-compliances] will always be there."

Yet, as the database system was initially rolled out, several coordinators felt that it was taking too long to classify each non-compliance. Moreover, some coordinators felt that this discretion for classification was resulting in inconsistent scores for different labs, which led Tom, a coordinator, to object:

> It isn't fair that [one] coordinator cites something as one thing and another coordinator does it else how. That isn't acceptable!

Natasha, who had earlier requested discretion in classifying non-compliances now asked:

> [Could] some [non-compliances] that are standard be automatically classified?

Features and functionalities could be both desired as well as feared. As seen in Table 6, text-boxes could be desired for their ability to present detailed context but feared for being too time consuming. The details in text-boxes also are not commensurate for the evaluation of metrics and trend assessment. Similar contradictions are seen for other features like drop-down options, default options, authorizations, etc.

Feature/functionality	Desired	Feared
– Text-boxes	– Allows presentation of context	– Too time consuming – Prevents evaluation of metrics – Impedes assessment of trends
– Drop-down options	– Quick to enter data into – Easy to compute metrics	– Reduces flexibility – Increases the possibilities of misinterpretation
– Default options	– Easy to enter data into	– Increases possibilities of inaccuracies – May define new roles and responsibilities
– Metrics	– Easy for data analysis	– Hide the context – Too much visibility
– Authorizations	– Allow control	– Increase visibility
– Automation	– Easy to enter data into – Easy to control process with – Easy to prove lines of responsibility	– Reduces flexibility – Increases possibility of misinterpretation

Table 6: Contradictory Features and Functionalities

Not all the contradictions seen in the above table are due to positional interests. Features such as authorizations generated conflicts across different positions. But other features like automation or text-boxes could be both desired and feared from the perspective of the same individual. The same individual could want the same information presented in a completely opposite manner, depending on what interest was paramount in his/her mind at that moment in time. When the fear of legal liability was very high, features like automation that portrayed Welldon favorably were more easily accepted even if they created the possibility of misinterpretation.

In summary, database elements come with trade-offs. There could be elements such as authorizations that compromised one party's interests as compared to another's. Or the same individual may be split between two separate ways to represent the same information because the two representations serve two separate, and often orthogonal, interests.

How were the trade-offs resolved?

When contradictions surfaced, designers had to resolve them. Which interests would the design elements represent? Would the non-compliances be reported automatically or would the designers provide room for discretion? Would the designers provide the EHS office with authorizations to view all information about the labs? Designers had to make a call on which way the design would tilt. They considered several factors in making their decisions. In particular, they usually tilted towards those actors who were more powerful or who complained the most, or towards those interests that were most prominent at that moment.

Power of power

While universities are supposed to be less hierarchical than other organizations, they are not immune to power dynamics. Pfeffer and Moore (1980) found university budget allocations related to departmental power, which in turn was a function of departmental grant allocation, and student enrollment. At Welldon, power came from the occupation that a person or a group belonged to. Given that this was a research institution, researchers and faculty PIs had strong clout as compared to administrators. Other sources of power came from status within Welldon. Inevitably, some departments were more powerful than others. This could be due to the size of the department, or the kinds of faculty members that occupied these departments. If the department was very large, or if the faculty members in these departments were particularly prominent, then the department got a lot more visibility. Also, if a department's labs were particularly hazardous, then they too became quite powerful simply because these departments usually had much more visible administrative representation in various design committees.

Such sources of power made some departments, such as Chemistry and Biology, especially powerful from the perspective of the database system. As a result, these departments also got to weigh in a lot when trade-offs arose. If the coordinator of a less visible department demanded something that was contradictory to the existing design proposal, it had less chance of getting accepted.

For instance, the coordinator from one of the less powerful departments requested a different grouping of the questions to be included on the inspection questionnaire. He felt that his department had several documents to maintain and therefore wanted a separate cluster of questions just around document maintenance. The IT designers heard this request but claimed that such unique "customizations" were going to be very costly and time consuming. For the more powerful departments, on the other hand, privileges often came in the form of exceptions to the process. When Chemistry, one of the most powerful and visible departments in the design process, also wanted a separate set of questions to be included in the inspection questionnaire, the IT designers agreed to make a separate questionnaire altogether for Chemistry. The rationale that the IT designers provided was that Chemistry had an established and well-working process in place. One of the other IT developers wondered why Nuclear Engineering did not get a separate questionnaire, even though they too had an established inspection process. In a small meeting, Dan, the IT consultant acknowledged that the Head of the Chemistry department had negotiated a special exception for Chemistry.

Exceptions were also given for authorizations. Coordinators of some of the departments were allowed to edit some of the observations from their inspections even after the inspection results had been submitted. This authorization was not available to others, and very few coordinators were shown the "back door" way to make adjustments to their inspection results. The EHS office staff justified this decision to each other with the rationale that these coordinators had always performed their responsibilities adequately.

Squeaky wheel gets the grease

The committees provided a forum for users to describe requirements and to object to design elements being proposed. Although most of these committees were open to all coordinators and EHS members, there were some people who were more vocal than the others.

Coordinators like Sarah in Civil Engineering always complained about the system being a "one size fits all." Sarah always sat in the front row of the room where the joint group met fortnightly to discuss the design. She raised her hand the most frequently to comment on (usually to criticize) the design. Often I noticed that Sarah broke the silence that followed a presentation by the IT designers as people mulled about the design details that had just been presented to them.

Given the very visible, and critical voice of Sarah, the key IT designers visited Sarah a lot more than other coordinators. IT designers would often be accompanied by some high ranking EHS official on these visits, as they tried to address Sarah's criticisms. At these meetings, IT designers agreed to make several exceptions and compensations to accommodate her needs, including changes to the way the information about lab spaces was organized. Such changes affected everyone in the system but were made to appease the most vocal critic.

Dominant (and shifting) interests

When the database was still in a more amorphous state, most users could only imagine the interests to be served eventually by the database system. And their fears and desires about database elements stemmed from these imagined interests that were valid at that point in time. However, as these interests shifted over time, the fears and desires also changed. These interests could shift due to some specific incidents or through observations from actual use. For instance, the interest that seemed most dominant to most people initially was that of accountability and evaluation. Designers and users knew that Welldon's prior "free hand" policy had failed to satisfy EPA and therefore the system was being created to control and evaluate the research practices being used in the labs. The impending EPA audit also contributed to making accountability and evaluation the dominant interests to be served by the database system. Therefore, coordinators like Natasha objected to any field that would portray them in an unfavorable manner. They did not want their non-compliances to be automatically classified as serious.

However, over time, as people engaged with the database system and realized the time that was being consumed in data maintenance, interests of efficiency became particularly strong. Coordinators also realized the potential of having inconsistent metrics assigned to the same non-compliance across different labs. These realizations around efficiency and consistency could only come with experience and reflection about the database. It led Natasha, for example, to ask whether some non-compliances could now be automatically classified. Such reflections about design made people understand what an interest really meant in practice, to themselves and to others. People like Natasha understood that addressing accountability that she imagined earlier in the design process came at the cost of efficiency and thus, she had to redefine her interest in managing accountability.

Interactions with other actors also led to a redefinition of existing interests and emergence of previously subdued interests. For example, before the actual design discussions, departmental staff could only imagine that the EHS office staff would create a system for greater accountability. But nobody in the departmental staff could clearly articulate what that accountability would entail. In fact, even members of EHS office could not have explained what the interest of accountability truly translated to in the database system. But as people interacted with each other and observed the fears and desires as well as the features and functionalities, they could get a better sense of what accountability meant to the EHS office. It meant, for instance, that departments like Chemistry that had already demonstranted compliance would be subject to less control than some of the other departments. Such understanding of the interests only emerged over time.

The interaction with the artifact and other actors also made interests like comparability more dominant than they had been in the earlier stages of design. As people realized that notions of flexibility could make the development of the database challenging, and outcomes difficult to evaluate, they started arguing more for comparability and consistency. IT designers had to change the design of the database system often to accommodate the shifting interests that emerged over time as people engaged with the database and with each other.

Some events also changed users' definition of interests. When the EPA audit was nearing, most users' prime concern was to portray themselves favorably. The interest of efficiency was subservient to this other interest. All effort in design shifted to completeness of information. There could be no inconsistency, and appropriate responsibilities for completing various information maintenance tasks had to be allocated, regardless of whether people wanted to do them or not. The threat of a failed audit made people more accommodating of requests made of them to take on various information maintenance roles. However, once the audit had been completed, and Welldon had satisfied EPA about its improved processes, the interests also shifted. Efficiency interests became paramount since people were no longer interested in entering the most complete information; instead they just wanted to have whatever information they could enter quickly in order to fulfill their data maintenance responsibilities. They were also no longer interested in any additional data maintenance responsibilities except for those most closely attached to their jobs. Again the designers had to change the elements of the database system to address the shifting interests. Simple check boxes, minimal detailed information, and the assurances of reduced use of text boxes became the order of the day.

The consequences of trade-offs, compromises, and the resulting complexities

As these contradictions surfaced, changes to the database system became increasingly more complex. Every change made would satisfy some people, or some interests, but ran the risk of opposition from one or more other actors or interests. Yet, the designers continued to try to accommodate requests for changes.

For instance, authorizations were constantly changed to accommodate various position-based interests. Several coordinators mentioned to the IT designers that PIs should have access to all the inspection results from their labs. The designers then granted view authorizations to the PIs. However, over time, these same coordinators realized that they may want to record information about the labs that they didn't necessarily want the PI to see. These could be notes about certain things that they had observed in the labs that they did not want the PI to see unless these observations became particularly egregious. So they again asked for authorizations to be changed. This time the designers had to change the design of the system so that it was possible to have separate kinds of authorizations for every field in the inspection system – the field for consequences could have very different authorization rights than the field for the coordinators' notes.

The most complex contradictions, however, surfaced around the standardized fields, metrics, and text boxes. Every change made to these resulted in some interests or some actors being dissatisfied. So the designers usually made further changes. Except these changes now generated yet more contradictions that were often more complex than the previous ones. In this way the design process became a dynamic system – tweaking the design in one place created ripple effects all around the system and required yet more tweaks, and so on until the process itself became almost explosively dynamic and the system increasingly departed from its original goals.

The dynamic design process

The complexity of the design process is depicted in Figure 12. This figure does not demonstrate all the possible design elements that the designers tinkered with but provides a sense of the contradictions involved in making most of the design choices.

If we start with the desire for evaluation, this transforms, over time, into a desire for comparability. The EHS office wanted to know how each department was doing but they also wanted to know how the departments were doing compared to one another and over time. The users within the departments, especially the better performing departments, also wanted to have similar results to show their performance as compared to the not-so-well-performing departments, resulting in a desire for comparability. The easiest way to compare entities is through the comparison of consistent numbers and bottom lines. Therefore, a desire for comparison translated to the desire for metrics and for consistency. Only if everyone was recording similar things could a comparison be made.

Consistent metrics, however, required the information to be recorded numerically. It would be very difficult to create a score for the lab if the only information available for the lab was in the form of some text. Textual information would mean a manual assessment of the information to create a score. The database's use of simple and standardized fields grew. Several meetings were held to discuss the options that would be incorporated in the drop-down menus.

As the database system started having more and more standardized, quantifiable fields such as drop-down menus, check boxes, and option boxes, concern arose among other actors, and at times, even among the same group of actors who had initially requested the metrics and standardized fields. The EHS office wanted the information about labs presented to them in the form of metrics. But the coordinators and departmental administrators feared that the metrics would lead to over-simplification and misinterpretation. Among those expressing such concerns were some of the same coordinators who had wished to have easy-to-fill check boxes and option fields.

As these fears were expressed, they resulted in a desire for contextual details. For instance, several coordinators wanted the ability to justify the rating that they had accorded to a non-compliance through some textual details. If they gave a really bad score for a seemingly minor non-compliance, they wanted the ability to explain their reason for doing so. The designers, as a result, added several text boxes to accommodate these concerns. These text boxes usually accompanied the more simple check-box and drop-down menu fields.

However, with time, as people used the database system and got a clearer sense of the efforts that data maintenance and analysis required, fears of additional effort grew. Contextual details would only amplify these concerns. Members of the EHS office feared that analyzing the contextual details would entail more effort, and coordinators and departmental administrators felt that they did not want to use the text boxes, especially when an alternative was available in the form of a drop-down menu, or a check box. Whenever possible, they would resort to using these simple-to-use fields. As these concerns grew, more meetings were held, this time only focusing on creating the best possible, most comprehensive, drop-down menu lists that would accommodate as many commonly faced situations as possible. There were also intense debates on what non-compliances could be automatically classified, and what non-compliances would automatically be assigned to someone to fix.

Standardized fields, however, produced other fears, this time around the lost flexibility due to the excessive use of standardized fields. Several users felt that they wanted the ability to store and to maintain information in ways most suitable for them, and not to be made to accommodate to a norm or standard. This time, the designers tried to address these concerns by adding special customizations that users could have for their forms. For instance, coordinators could now decide whether they wanted the inspection report to be sent to the PI automatically, or manually, after making appropriate changes. These customizations made several users happy but increased the strain on the system.

The designers often resisted these kinds of customizations because of the additional development work for them. Dan, the IT consultant, often claimed that such customizations "defeated the purpose of the system." Therefore, while some customizations were created for the users, often the users were asked to adhere to the standards set in the system.

Desire for evaluation also led to ambitions for more and more information. The EHS office wanted information about inspections, what non-compliances were found, who was present, who was responsible for the fix, was the non-compliance corrected, who corrected it, when it was corrected, etc. With an explosion of information came the fear of visibility. The users wanted the ability to explain any seemingly cryptic information about themselves and their units. They also wanted the ability to have their own customized versions of reporting. However, as is evident in the dynamic cycle already, contextual details and customizations generated their own ripple effects.

Given that almost all design elements had fears and desires associated with them, every change made to the database system resulted in these fears and desires being expressed. Moreover, with the passage of time and with greater articulation of the interests being served by the database system, both the fears and desires became stronger. In this way the design cycle continued to escalate in a series of fears, desires, and changes ultimately affecting the shape of the database system and its ability to satisfy the original goals.

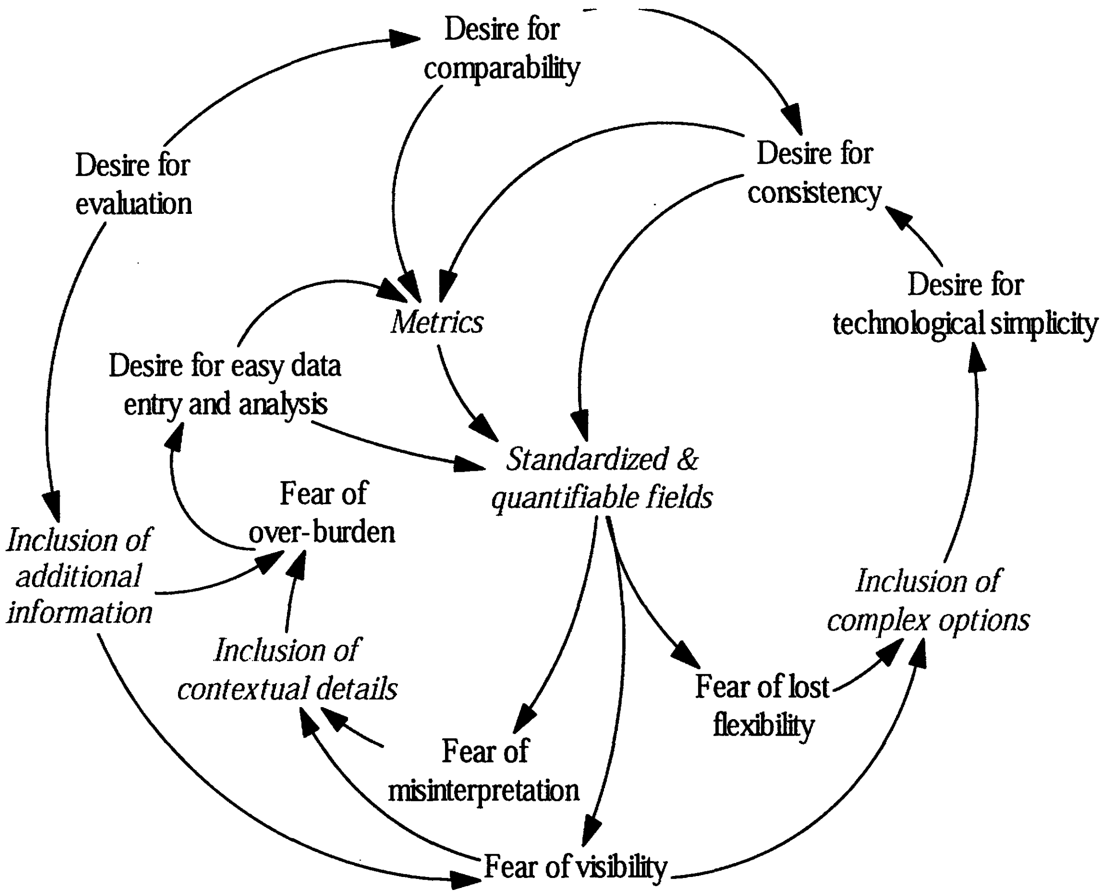


Figure 12: The Dynamic Database Design Process

What exacerbates this complexity?

System design is almost always iterative and complex. Systems, after all, are attempts to capture the messy details of the real world into a set of explicit, and formally defined rules. But there are numerous factors that make system design even more complex, including the number of users being served by the system, and the number of interests accommodated in it.

Number of people being served by the system

As the database tries to serve more people, the potential for contradictions across stakeholders magnifies. Imagine designing a customized system for a single individual that nobody else would use. It would be much simpler to accomplish the desired goals through that database system. However, with increased number and diversity of stakeholders being served by the system, the probability of clashing desires also increases. It becomes that much more difficult to appease all the individuals for whom the database system is being designed, and the contradictions across them become more inevitable.

Should it matter whether these multiple and heterogeneous actors are involved during design or relegated to their role as users? When a system is designed for use by several heterogeneous actors, but deploys the voices of few during design, the system use is not necessarily more aligned with its original goals. In fact, this lack of alignment between users and designers is suggested as a possible cause of failure of many off-the-shelf enterprise systems that are unable to sufficiently incorporate the requirements of the users, who are not co-present with the original designers of the enterprise system packages. Scholars have cited poor communication as one of the key reasons for Enterprise System failures (Sarker and Lee 2003; Soh and Sia 2004). A good system design process is portrayed as one that involves different opinions and voices. However, the Welldon process displays the dangers of being overly participatory during design.

Database design is a highly speculative exercise contributing to the dynamic expression of fears and desires. During design, people can only imagine the uses of the database; based on what they imagine, they express fears and desires. Once people start using a database and start entering data into it, they become more familiar with how it is being used and try to devise ways to emphasize favorable representations. They may find ways to evaluate others that are not based purely on the written records. They may not need to evaluate as much as they thought they would. In fact as the EPA audit concluded, people at Welldon got a better sense of what the auditors were expecting. They realized that many assumptions that they held about the EPA requirements were not very accurate. EPA did not necessarily want a very rigid system; they wanted a process of accountability that did not need to be accomplished only through a formal system of records. Other fears of misinterpretation, for instance those around consequences, have been found to be less intense. The staff in the EHS office calls up the departments to ask for more details every time a consequence is actually reported in the database.

But this benefit of hindsight is missing during the period of database creation, when the uncertainty about the possible uses of data provokes active imaginings among the database creators. People discount the ways in which workarounds may be possible to manage both their fears and their desires. They do not, for instance, know what the EPA requirements may be, or how the EHS office would interpret the data. They don't know if the EHS office would use other mechanisms to supplement the information in the database. Such uncertainty is fueled by the intense discussions around the features and functionalities of the database, which enhances the importance of the database, creating a perception that the database would play a far more significant role in the employees' lives than other mechanisms that had previously existed. As they envision ways in which the data could ultimately be used, they argue for inclusions and exclusions based on these fears and desires.

Number of interests being served by the system

Arguably, a system with a singular interest to serve would be simpler to design. Imagine a system that was being used primarily for accountability. Perhaps interests of efficiency and consistency would be there, but if they were subservient to the interest of accountability, then the complexity would be reduced simply because the main concern would be to gather as much information as possible to enable evaluation. There would, of course, be fears of evaluation by those being monitored, but the desires for information, and fears against that information, would not interact dynamically with fears and desires due to the other interests.

Similarly evaluating an individual's performance would be far easier if attempts were not being made to compare it to others' performance or to past performance. Evaluation would mean inspection questions that assess how an individual lab is performing on measures that are relevant only for that lab's context at that point in time.

The design becomes complex as systems are intended to satisfy multiple interests. Even when they do not actually end up fulfilling multiple interests, as long as people imagine multiple interests from the system, contradictions appear inevitable. As seen in Welldon's database system, eventually the system could have at most one or two dominant interests – accountability could have been relatively easily observed through EHS authorizations to view lab's inspection evaluations but became difficult to establish through the database when attempts were also made to make these evaluations comparable and fast. Including these multiple interests created the dynamic and complex process seen at Welldon. Ironically, the iterative design ended up compromising all three interests. The database at Welldon became a complex smorgasbord of features and functionalities that only partially created accountability; it saved some time, but not always; and it enabled some consistency, but with multiple exceptions. The compromises made in the system design had direct implications for the goals that could be served by the system.

Consequences for the original system goals

In the background chapter I described the goals that the database system was expected to serve: (1) to recognize gaps in regulatory compliance, (2) to continuously improve research practices, (3) to help Welldon as a whole become a safer work place, and finally (4) to create self-accountability so that the organization could observe and check itself. I now want to revisit these goals and show how most of these goals, at least as intended by the original designers, were compromised. I examine each separately.

Recognizing gaps in regulatory compliance: Given the most immediate need to satisfy EPA and other regulatory authorities, this particular goal was most carefully weighed during most discussions. Ultimately Welldon passed the audit, and so this goal was certainly served in a significant way.

Yet, audits rarely observe actual practices. Records become proxies for research practices and it was the records from the database that were the focus of this audit. This was despite the assurances from the EPA that they were interested in observing the institutionalization of more effective research practices at Welldon. Even members of the EHS office believed that the EPA was more interested in the research practices than in the records. One of the EHS officers assured participants in a meeting that "the EPA requires inspections, but not records from inspections. For good practices purposes, we might want to keep records, though." But records were the most easily observable proof of the inspections. While the EHS office required the maintenance of records of bi-annual inspections, they agreed not to require the departments to maintain records of their weekly internal inspections. Most departments were relieved about not having to maintain these records but some were also uncomfortable. Kate, a coordinator said that ever since her lab had stopped maintaining records for weekly inspections, she was not sure whether these inspections were happening or not. She wanted her lab to maintain the records even on weekly inspections.

Records, however, do not always accurately represent research practices. At Welldon, the internal inspections of the lab were always announced ahead of time. When some EHS office personnel proposed having unannounced inspections, the coordinators argued that chances were high that the inspectors would not be able to find the right people to ask questions during the inspection. By having announced inspections, people in the labs could be present to answer any of the inspectors' questions. Of course, this largely defeated the purpose of the inspections because the lab could "gear up" for the inspections given the two-day notice that they were given before the inspection.

In effect, then, observing compliance or lack thereof was made possible through (announced) inspections, and auditing research practices was made possible through the records from these inspections. The long -- and often tenuous – link between compliance and records makes it difficult to assess whether Welldon was actually monitoring all non-compliances and whether it was in fact recognizing gaps in its regulatory compliance.

Both the design of the database and the records entered into the database were intended to *demonstrate* compliance. Before the impending EPA audit, several EHS office administrators as well as several coordinators spent innumerable hours trying to ensure that all records were in order and complete. This is no different from what occurs in most organizations before an audit. In fact, it is very close to what I observed in the organization that I had worked at before graduate school. The month before our factory was scheduled to have an ISO9000 audit, we all spent days and nights filling in records. Our factory passed the ISO9000 audit! However, the records at the factory did not necessarily represent the practices on the shopfloor. Similarly, the inspection records at

Welldon did not always represent actual practices in the labs and are not always able to recognize actual gaps in regulatory compliance.

Continuously improving research practices: The architects of the database system also wanted the system to facilitate continuous improvement in research practices in two ways: (1) ensuring that people were trained in hazard prevention and control, and (2) sharing best practices across labs.

Just like inspection records are a proxy for research practices, training records are a representation of knowledge enhancement. The records on training in a lab did not necessarily mean improved research practices. On the one hand, the presence of records compelled people to recognize their training needs. But the automatic email notifications about missed training became so frequent that one of the student researchers told me that he had started deleting these email notices without even reading them. The automatic notifications were a way to ensure that there was a process to recognize the missed training. But if ignored, these elements of the database did not necessarily improve research practices.

As for information about shared best practices, the desire for consistency and efficiency meant that no separate field was created to record best practices. As a result, coordinators stopped recording information about any good practices in their research spaces and there was little formal opportunity to share knowledge about practices across labs.

Becoming a safer workplace: Besides improving research practices, records were meant to enhance safety by identifying any particularly unsafe practices. Trend analyses were also meant to improve safety, as analysis of inspections and accidents would flag any particularly egregious non-compliances and risks.

Desires for consistency sometimes made it difficult, however, to identify unsafe practices. The standard form for training could not actually identify any training specific to a particular lab. For example, one lab in marine biology required researchers to go out on boats to the ocean to collect specimen. Yet, in an audit, the PI of this lab acknowledged that the records did not capture whether the researchers had received any training with boats and swimming.

Fear of visibility also made it difficult to prevent all accidents. How could the research environment be very safe if one could not ascertain how long a lab had been out of compliance? The decision not to record any dates made it very difficult to do this. If a lab was found to have had a radiation exposure, the records would not show the duration of that exposure.

Fear of visibility further prevented any sharing of information between labs. Jane, a safety rep in one of the labs, mentioned that researchers from other labs frequently collaborated with and worked in her lab. On being asked whether these people were trained on the hazards that were present in her lab, she noted that she could not know this given that these people did not belong to her labs, "I can't see other [lab's] information."

Trend reports were meant to flag any particularly risky locations or work practices but trend analysis was not always possible. For the data on accidents, trends were supposed to indicate what some of the most accident-prone areas were. To make Welldon a safer workplace, this information should have existed for all areas at Welldon that a researcher would potentially visit, including the parking lots used for parking his/her car.

But to record such information, one had to have a clear list of all areas at Welldon. This information existed for the research spaces, but was not available for the public spaces. So one could track how many accidents had occurred in a lab space over the last five years, but to say the same thing for a parking lot would be very challenging. Part of the reason that this list of public spaces did not exist was because it was difficult to assign an owner to a public space. While the PI was supposedly responsible for a lab, there was no single individual responsible for the parking lot. The lack of a list of public spaces led to a decision to include a text box to describe the location of an accident, instead of a drop-down menu of all spaces that one could choose from. This then led to the loss of information on accidents in public spaces, at least in a clear, trendable form. Given the desire for easy data analysis, it is not unreasonable to assume that there would be very little done with any data, if it exists, on accidents in public spaces.

Eventually the desire for consistency, the fear of visibility, and the desire for easy analysis of data made the database less able to identify unsafe areas and practices at Welldon.

Creating Self-Accountability: The establishment of processes to track and record observations about practices was thought to be a precursor to increased self-accountability. Ultimately people would learn to distinguish good practices from the bad, fix any bad practices, and fear consequences for not doing so.

This concept of self-surveillance is discussed by several researchers (Barker 1993; Sewell 1998) in contexts of team work, and in modern societies and organizations. Barker terms such control as "concertive control," which he defines as something that the workers achieve "by reaching a negotiated consensus on how to shape their behavior according to a set of core values, such as the values found in a corporate vision statement" (1993, p.411). In this way, the workers would regulate their own behavior instead of relying on external controls imposed by rules or the technology.

At Welldon, the system was similarly supposed to create a culture of self-accountability among the researchers. The first step in this was to create the inventory of lab spaces and assign a person responsible for that space. EHS staff hoped that this would make PIs more accountable for all actions, practices, and incidents in their lab spaces. The notifications, the authorizations, and the defaults were also meant to create this same notion of self-accountability. As people interacted more with the system, EHS staff hoped that the awareness of responsibilities would increase.

Arguably, this goal, too, fell short of the original intent. First, the decision not to include information about consequences in the database system defeated the objective of concertive control. The fear of visibility in the case of consequences was so high that the designers and the EHS staff simply could not create a consensus for including the information on consequences. Consequently, while the database showed several instances of non-compliances, or incomplete fixes, it was very difficult to know whether anyone had been penalized for them or whether corrective actions had been taken.

The hope for greater social control also did not reach very far. The culture of deference to PIs was far too strong for the administrative staff to hold PIs accountable. One of the PIs admitted to me that she was not quite sure of her responsibilities: "I didn't sign any form to say I am responsible for this place. I guess [my coordinator] fills some form." Instances of staff completing forms for their PIs abounded.

Ultimately the system, in its attempt to make PIs more accountable, simply ended up with bureaucratic forms to be completed by administrative staff, some of whom were especially hired to perform these tasks.

Summary

Database design involves several contradictions. Contradictions occur not only across people, but also across interests that are not necessarily position-centric. Contradictions are possible within the context of the same person, because of shifting goals, improved articulation of system impact, or just a simple desire to want it all. The same person who wants efficiency may also not want to deal with the possibility of misinterpretation.

The artifact, the database in this case, helped surface these contradictions because the process of design helped surface the fears and desires of the people and revealed the different and contradictory ways that people wanted to represent and use information. The speculative nature of the design heightened these fears and desires. Both the designers and the users of the system discounted the possibility of mechanisms other than the database to achieve some of the purposes, making some features highly desired. But people also discounted the possibility of workarounds, as a result of which some elements were feared more. Attempts to resolve these contradictions through design changes resulted in ripple effects across the entire system, triggering still more fears and desires, and further changes. The escalating nature of these fears and desires led to the system departing from its original goals.

The design process forced a discussion around the challenges involved in creating compliance and sustainability. Welldon passed the EPA audit. The database is being used to uncover some patterns and trends. And some PIs are much more involved now in the management of their labs than they had been in the past. Yet the system falls far short of its original goals.

VII: Implications and Conclusion

In the past few chapters, I have discussed the system design process at Welldon. I now want to use this concluding chapter to highlight some key implications and contributions – both for researchers and for practitioners.

My investigation has been about organizational change, and how technological artifacts are used to create such change. Here I consider how my work departs from, and contributes to, the existing research on technology-driven change. My investigation reaffirmed the value of studying a change process through the micro-interactions. This process then allowed me to question two methodological biases in the literature associated with (1) the actors and their aspirations during change; and (2) the artifact itself. I next discuss my arguments around the research approaches to change.

Examining organizational change

Change is often iterative rather than linear, collective rather than dyadic, and embedded in the social interactions that shift the status quo. These aspects of change make its examination highly interesting and yet challenging. How does one observe a process that is so complex? My investigation at Welldon provided me the fortunate opportunity to observe the change process closely through the micro-interactions around the design of database elements. The changing conceptions of the interests and the artifact at Welldon led me to question two methodological biases in the research on IS and change: (1) emphasis on actors and power conflicts; and (2) underplaying the materiality of the artifact.

Change from the perspective of actors and power conflicts

Several scholars have dealt with the influence of, and impact on, politics in IS development, impact, and use (Markus 1983; Myers and Young 1997; Robey, Farrow, and

Franz 1989). In an examination of this research, Jasperson et al. (2002) argue that while the conceptions of politics differ across researchers, politics generally involves considerations of "authority, centralization, decision rights, participation in decision making" as well as general considerations of influence or power (p. 399). IT Studies highlighting the role of politics in design, or use, examine either (1) the role of technology in shifting influence by changing a group's ability to participate in organizational decision making or by changing it's access to information (e.g., Tan, Wei, Watson, Clapper, and McLean 1998), or (2) the role of differential influence in shaping the IT artifact, or the meanings associated with it (e.g., Barki and Hartwick 1994; Franz and Robey 1984). Some research, however, argues that this influence is mutually reinforcing: IT use and development are shaped by power dynamics, while the IT also shapes the power dynamics (e.g. Boudreau and Robey 2005).

In most of this literature, politics is explored by identifying parties with differing interests, and how the influential resources and skills vary across the differentially situated and interested parties. Indeed Bradshaw-Camball and Murray (1991) argue:

> A truly comprehensive theory of politics in organizations must adequately answer three critical questions having to do with: (1) Structure – who are the parties involved and what are their interests? How much power do they have? What are the bases of power; (2) Process – how is power used in pursuit of each party's interests?; [and] (3) Outcomes – when the process is over, who gets what? What is the impact on the ongoing relationship of the parties and on the others who comprise the organization and its stakeholders? (p.380).

Following the classic definition of politics in political science, "Who Gets What, When and How" (Lasswell 1950), the research begins from the assumption that without a specification of "who," one cannot describe politics. These different kinds of actors are typically identified as stakeholder groups, each with different, often competing interests. The stakeholder categories can be as broad as users and designers (Gallivan and Keil

2003) or more narrowly defined in the form of consultants and hospital administration (Bloomfield and Danieli 1995); or the market leaders, brokers and multinational groups in the insurance industry (Heracleous and Barrett 2001). In IS research, it becomes almost essential to define every such social group to be able to study the politics of a process. Such a definition is perhaps required because there are always tradeoffs among the various functionalities and forms of the IT system that differentially appeal to the different user and development groups. Thus conflicts between groups appear in most development and use processes. In fact in several cases, the dominant conflicts occur across broad stakeholder groups when the aspirations of an entire group are antithetical to another group's. For example in Lapointe and Rivard's (2007) study, the patient-care information system in a hospital was embraced by the nurses, but rejected by the physicians because it sought to change the way patients' prescriptions were recorded in the system. In the previous process, physicians often asked nurses to enter the prescriptions in the system even though they were themselves supposed to do so; but the new system prevented nurses from entering the prescriptions, forcing the physicians to make the effort and shifting some of the power to the nurses.

However, political conflicts need not occur only because of differing group interests or aspirations. At Welldon conflicts occurred (and were resolved) for a variety of reasons. Group aspirations and power interests constituted but one of these reasons, albeit an important one. With accountability as one of the driving concerns, power conflicts often arose between different groups of actors – those who wanted to oversee, monitor, and control the actions of lab and department personnel at Welldon, such as members of the EHS office, and those who were being surveilled, such as faculty researchers. Compared to the prior situation where the faculty members were generally independent of the EHS office, calling upon them only when faculty felt themselves in need, the IT artifact became a means of devolving control to the EHS office. As a result, struggles arose especially around features like authorizations that specifically sought to change the existing power relations. Power differentials also played a role when contradictions became particularly challenging. At such times, departments or individuals with symbolic or structural power could weigh in with their perspectives.

However, the actors' power was not the only thing determining the process or the outcome of the database design. The power conflicts interacted with other interests such as efficiency and comparability in shaping both the process and the outcome. At such times, the process became political and conflicted not because the actors with distinctly different interests clashed but because interests shared among the actors and across different groups clashed. As discussed in the previous chapters, the same actor could be an adopter as well as a resistor – he or she could desire a feature from the perspective of one interest and fear it from the perspective of another. These misalignments occurred within and across occupational group boundaries.

Actors are rarely monolithic, having a variety of interests (Mackay, Carne, Beynon-Davies, and Tudhope 2000). Mackay et al. (2000, p. 738) cite work by Friedman et al. (1989) which classifies users into six different types: "Patrons (who initiate the system), clients (for whom system is intended and used), design interactors (those involved in development), end users (operatives), maintenance or enhancement interactors, and secondary users (such as those displaced, deskilled or otherwise affected)." Such a classification, although simplistic, illustrates the point that every stakeholder group, defined by organizational role and position, could be further classified on the basis of different roles with respect to IS rather than their work process. Silbey et al. (2008) further reinforce this argument that actors manifest different, and often conflicting, faces depending on the context:

> Although divisions of labor demand dependable role performances, few persons enact solely their formal scripts, even in highly stratified organizations with complex divisions of labor. Because human beings are "wholes" (Selznick 1949; 1969) performing roles (Goffman 1967; 1959), their wholeness precludes exclusive role performance. Much happens in organizations that is not predicted nor explained by formal roles and responsibilities. Indeed, tracking excessive or diminished role performances has preoccupied many twentieth century sociologists of organizations, the law, and regulation in particular. Researchers have often labeled such performances organizational failures, or 'gaps' between the law on the books and the law in action (Silbey, Huising, and Coslovsky 2008, p.2).

Perhaps the legacy of research on class conflicts has infected the IS literature. In the IS literature, classes have been replaced by the stakeholder groups that are wrestling for power from one another through the artifact.

Eventually, the process of system design is political but as my work at Welldon shows, politics encompasses not just the control of particular institutionalized groups but the interacting and conflicting interests that do not attach directly and simply to different groups, making it difficult to analyze the process at the level of stakeholder groups or even individual actors. Here, politics describes the process through which decisions need to be taken about what interests or goals, rather than persons or groups, would be satisfied and what would be forfeited. In that sense, the process of systems design is political but in the broader sense of the word that is implied but not elaborated by Knights and Murray (1994, xiv):

> By politics we mean the very stuff, the marrow of organizational process; by politics we mean managerial and staff concerns to secure careers, to avoid blame, to create successes and to establish stable identities within competitive labor markets and organizational hierarchies where the resources that donate relative success are necessarily limited.

Knights and Murray seem to acknowledge that politics is about self-serving interests that may be associated with success in organizational processes or in career issues and identity. If we adopt this broader view, then there could be many conceptions of success, not all of them converging for an individual or a group. Some may, in fact, be contradictory and diverging, even from the perspective of a single group or an individual. We saw this in the case of Welldon, where some individuals viewed both accountability and efficiency as instrumental to success, although they occupied very different positions and may have had competing self-serving concerns. Knights and Murray go on to argue:

> "Power relations are multiple, discontinuous and heterogeneous and they are often inconsistent and contradictory with one another. For these reasons they may stimulate as much resistance as consent, change as continuity and instability as order" (p. 37).

A focus on organizational goals and interests instead of stakeholder power may provide a more nuanced analysis of an IS design and use process. Such a focus, although empirically challenging, would be inclusive of power but would treat it as one of the many interests that actors struggle with in a political systems process. It would also prevent an artificial boundary across actor or actor groups based on power relations.

A final note, from a managerial perspective, concerns the need for diversifying the conception of politics. In most development and use processes there are typically enough pre-existing power dynamics among different groups without scholarly research exacerbating the 'us-versus-them' conceptions as the central issue. A focus instead on organizational interests may promote a more collaborative approach where mechanisms are sought to define the shared goals and interests and to manage conflicts and contradictions that arise.

Change that includes the material artifact

Existing research cites at least two reasons why a closer examination of material artifacts is necessary during an IS design process: (1) artifacts may constrain and enable the range of actions possible during use; and (2) they allow communities to understand others' interests and aspirations. The inscription literature, described in the first chapter, especially in the realm of Science and Technology Studies addresses the first point (Berg 1998; Latour 1992). Material and informational artifacts have the potential to define conventions of behavior, legitimacy of actions, and even create visibility and invisibility for aspects of the artifact or work (Berg 1998; Bowker and Star 1999). The literature on boundary objects (Bechky 2003a; Carlile 2002; Star and Griesemer 1989) is most significant in stressing the second point about the role of artifacts in articulation. For example, Henderson (1991) discusses the use of informal sketches -- by designers, engineers, and those in production -- to enhance the understanding of the task that each group needs to do. Such informal sketches are invaluable in communicating ideas across work groups that would otherwise be difficult to explain.

Despite the growing emphasis on material artifacts, there are still relatively few attempts to open the black-box of technology (Kling 1991; Monteiro and Hanseth 1996). Orlikowski (2006) compares material artifacts to scaffolding used in construction that extends, connects, stabilizes, reconfigures and transforms human agency. Material artifacts need greater definition than is afforded to them in the current literature. The literature arguing for technological determinism does focus on the artifact but gives undue agency to it. It assumes, for instance, that introduction of a new technology is going to create greater participation (Tan et al. 1998) or greater control (Saunders 1981). Artifacts play an important role in our lives in how they constrain and enable us, how they create shared understanding, and how they create visibility but not necessarily as *the* agents for all these changes, since, as we know, uses often depart from the intent of the designers.

In most IS research, the emphasis is more on the entire information system such a health information system, or certain functionalities of the system such as some budgeting module (Myers and Young 1997). Rarely are attempts made to examine the technological artifact in terms of its components. In my analysis at Welldon, the components of the database played an instrumental role in articulating change, and in triggering fears, desires, and imagined interests. Actors imagined, realistically or unrealistically, that the features, functionalities, and fields of the database system had strong implications for how they would be doing research, managing risks, and controlling researchers. Through this process of engagement with the artifact, they could situate their interests, translating them into fears and desires and eventually transforming the artifact too.

It, therefore, helps to decompose an artifact into its components and examine how the interests are shaped by these components, and how the components themselves formulate, breakdown, reconfigure, and stabilize.

Of course the components, or at least their visibility, changes at different stages of the technology lifecycle. When the artifact is more fluid, components are more visible, although still having asymmetric and emergent visibility depending on the focus of the design process; an artifact that is more black-boxed may elicit interests and emotions that pertain to its more holistic form. Yet, an understanding first of the components of the artifact, as seen from the perspective of the actors engaged with it, would help us better understand how actors and organizations interact with the artifacts, how they make sense of them, and how they understand their own and others' interests.

There is implicit wisdom in the saying that we share a love-hate relationship with technology – the epigram aptly recognizes that technology often evokes contradictory emotions as diverse as love and hate, fear and desire -- and understanding these contradictions requires analyzing the components of an artifact.

Studying changing and emergent interests through micro-interactions

Ultimately my investigation at Welldon, which examined the micro-interactions of the design process, allowed me to observe the interests of actors in a new light. Studying the micro-interactions affords a view into the socio-technical world that favors neither the social nor the technical, but creates a window to observe the simultaneous creation of both (Orlikowski 1992). Orlikowski (2002) invokes the socio-technical in discussing "knowing in practice."

> Knowledgeability or knowing-in-practice is continually enacted through people's everyday activity; it does not exist "out there" (incorporated in external objects, routines, or systems) or "in here" (inscribed in human brains, bodies, or communities). Rather, knowing is an ongoing social accomplishment, constituted and reconstituted in everyday practice. As such, knowing cannot be understood as stable or enduring. Because it is enacted in the moment, its existence is virtual, its status provisional (ibid: p.252)

Knowing-in-practice implies that knowledge is only meaningful when enacted and embedded in social actions. My observations at Welldon reaffirmed the importance of this practice view suggested by Orlikowski in also examining interests. The interests that I discuss in the previous chapters were not some pre-defined concepts that existed outside the practices of the actors involved in design. Just as knowing is observed and realized through the social interactions, interests too are only conceptualized and internalized through a process of engagement with other actors and the artifact. Moreover, enacted interests, similar to knowing, involve reflection and improvisation as people encounter new challenges and new contexts.

In the case of Welldon, the micro-interactions enabled me to observe the ongoing reflection and reformulation of interests as people encountered new features and functionalities in the artifact, and new arguments in the meetings. As actors interacted with one another and with the emerging artifact, they thought they could understand how interests were being translated through the medium of the artifact. Both the emergent artifact and the emotions attached with it allowed the actors, and me, to understand the contradictions that had not been visible before, which in turn helped them redefine existing interests, and even discover new ones. For example, if asked, most people at Welldon would agree that efficiency was a goal to aspire to. However, they discerned the contradictions between efficiency and other interests only when discussing their conceptions of efficiency, and seeing its manifestations in the database. They then realized that efficiency came with a risk of misinterpretation. The conceptions of efficiency thus had to be recalibrated to incorporate the tensions that surfaced within their understandings, practices, and the artifact.

The design process also helped actors define entirely new interests. The interest of comparability was almost non-existent in the initial stages of design. But the desires for efficiency and fairness led to an enhanced interest in comparability. Understanding the way data would be captured through fields like drop-down menus enabled people to conceptualize the possibilities of comparison. These engagements with the artifact, and the attached emotions helped elicit whole new interests previously unconsidered.

Such a conceptualization of interests as being emergent departs from existing research, which often treats interests as pre-defined and largely unchanging (Hirschheim and Newman 1988; Markus 1983). Even if the actors observed in the research have not quite understood the interests and agendas initially or explicitly defined them, the research typically defines these interests upfront and then examines the change process as a consequence of accomplishing, or failing to meet them. For example, the interest of the actors in a technology could be its time-saving potential and when this interest is not realized, they end up resisting it (Markus 1983). Or the interest could be that of power and control which leads to resistance by some groups (Myers and Young 1997). Or the interest could be that of the designers in steering the users in desired directions (Woolgar 1991). These interests are assumed to be stable over time as people interact with the technological artifact. Rarely are interests themselves shown to be discovered or even changing during the change process. Notable exceptions include the research by Bowker and Star (1999) and Elmes et al. (2005) who show how interests shift and contradictions are discovered. In Bowker and Star's work, the nurses did not start by explicitly defining their interest in visibility but started understanding it better as they saw some of their work-practices being rendered invisible by the choices in the classification scheme. Similarly, in the work of Elmes et al., the use of an enterprise system helped actors understand the panoptic potential of the technology but also helped them see its ability to empower. My examination at Welldon corroborates the findings of these researchers that interests are emergent and need to be treated as such in research.

In fact, as shown in Figure 13, the interests, the artifact, and the emotions all shaped one another in a highly iterative process at Welldon. As argued above, the interests were defined and understood with the help of the emergent artifact and the fears and desires. The emergent interests shaped the requests for changes in the database as well as the way people reacted to the database. Finally the reactions to the database and the actual features and functionalities shaped one another.

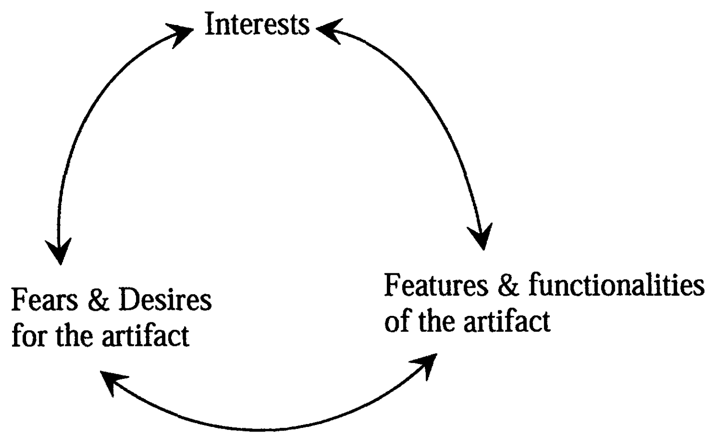


Figure 13: Emergent Interests, Emotions, and Artifact

Implications

The system design process at Welldon highlights several problems with the way systems are designed, and the assumptions that are held by practitioners and researchers about the "right" ways to design these complex systems, and the uses to which they may be put. I next question some of the received wisdom about systems and system design.

Trade-offs in artifacts -- Rethinking one size fits all

My analysis of the system design process at Welldon suggests a need to rethink the notion of one-size-fits-all artifacts. Technological advances have enhanced our desire to design and use artifacts that minimize the need for other devices and mechanisms. We see this with the development of new gadgets such as the iPhone that combines the phone, mail, video player, electronic diary, as well as a music player into one tiny device. Blackberrys and other personal wireless devices promise the dream of constant connectivity and increased engagement with the colleagues with whom the owners are communicating. However, as researchers have shown, increased engagement may in fact only be superficial as it goes hand-in-hand with increased withdrawal from other forms of communication, including face-to-face interaction (Mazmanian, Orlikowski, and Yates 2005).

In Enterprise Systems as well, contradictions are inevitable, and even more likely given the highly integrated, seamless, and standardized world that they promise. Elmes et al. (2005) found instances of both empowerment and disciplinary power at the organization that they observed. The ES provided the employees with better information that enabled them to do better planning and thus become more empowered. At the same time, this visibility became a double-edged sword – it made those people using the system objects for greater visibility. Similarly they found another contradiction, which they term "Reflective Conformity." The ES embedded many rules and authorizations within the technology that created process controls. However, since there were frequent breakdowns, the employees realized a need for greater reflection about an integrated organizational process so that patches could be applied. Markus et al. (2000) hint at similar trade-offs in ES implementation. They argue that success could be measured in many different ways in an ES implementation. Moreover, success in one stage does not imply success in another stage. Often in fact, success along one dimension in a stage of deployment would mean failure along that dimension in another stage.

Weick (1979) uses the metaphor of a clock to describe the trade-offs in the three attributes of good research: simplicity, accuracy, and generalizability. At noon, the clock completely satisfies generalizability; at 4 pm, the clock satisfies accuracy, and at 8 pm, it satisfies simplicity. At any time on the clock, only two of the three aspects could be satisfied. Therefore, organizational researchers need to decide what attributes to aim for in their research.

Technological design is like Weick's clock. It would be almost impossible to satisfy all the interests and all the goals aspired to by the designers. The overall goal of the system is accountability through information feedback and behavioral response. Efficiency demands standardization but at the same time impedes accountability. The database may provide consistency by stripping away the details of an inspection to achieve standardization but it will inhibit decision-making, and responsiveness, and possibly even safety. Standardization permits comparability and consistency, and thus some form of fairness, but absence of detailed information encourages misinterpretation. Nonetheless, attentiveness to variation is time consuming and impedes efficiency.

Systems typically try to accomplish multiple goals. My research at Welldon is further testimony to their complexity and challenges. Contradictions are everywhere and hoping for a system that accomplishes all is perhaps unrealistic. While the tensions resulting from these contradictions cannot be completely eliminated, it may help to decide which interests are more important than the others and then decide what to forego. Foregoing some would not necessarily mean that those interests would not be satisfied at all; it only means that a single artifact or system cannot satisfy all, but some other mechanisms or artifacts could be used to satisfy the goals set aside. In thinking about these alternative mechanisms, it becomes important to consider the several informal mechanisms available to organizations.

Bridging formal with informal

Modern technological systems, with their promise of all-encompassing solutions create a risk of neglecting the informal mechanisms that would otherwise facilitate control and coordination. Several scholars have shown the importance of informal mechanisms in mitigating deviance among employees (Hollinger and Clark 1982; Kraut 1976). Even in the ostensibly 'pure economic' transactions, trust, reputation, guilt, and shame play important roles in coordinating resources and actors (Kandel and Lazear 1992; Uzzi 1996). Schultze and Orlikowski (2004) examined the relationships between sales reps and insurance agents in a health insurance intermediary that would provide information about insurance plans to independent agents. The sales were largely dependent on the social capital earned by the sales reps in engaging directly with the insurance agents. The information system, deployed to increase transactional efficiency, actually eroded the trust earned by the sales reps.

In the case of Welldon, the informal mechanisms existed in the relationships that several members of the EHS office shared with the people in the labs, or those relationships that the lab safety officers shared with other researchers and PIs in the labs. These relationships were not foolproof, but ensured the accomplishment of several tasks. Lab people could call the EHS office members in case of an accident or a spill. Safety officers could go to their PIs and report a researcher who was not cooperating with safety practices. Scientists could watch each other and reprimand those who were creating unsafe environment for themselves and for others around them.

The management system was intended to be a vehicle to supplement these informal mechanisms. Instead, as the design continued, people got so mired in the intricacies of the design that they often tried to supplant the informal mechanisms with formal mechanisms. For instance, there was a long discussion about how the "system" would communicate to someone that they had not performed the fix that they were responsible for. After several minutes of discussion, someone suggested that "I would just pick up the phone and call." Periodically the IT consultant reminded the staff in the EHS office and the coordinators that "the system is not a substitute for people." And yet, people continued to try to create a system that left no loopholes. Except, as I have shown through repeated examples, the system simply could not accomplish everything, and in trying to get it to do this, the design process became all the more complicated and negotiated. In fact, it presented the risk of diluting the prevailing informal mechanisms that were already at work. A big factor in the informal mechanisms is the trust between actors that allows them to communicate with each other. However, in trying to formalize the informal communication through written records, the trust was often eroded.

Addressing the contradictions through technological solutions doesn't always help, and in fact may exacerbate the issue by merely fueling more trade-offs and negotiations. The formal structural organization is very different from the cliques that actually have the power and that get the work done (Dalton 1959). Similarly, the formal IT systems may have little power to get the work done. They are supplemented by, and hence need to be studied along with, the other mechanisms that are operating. Technical resolutions, through database systems, need to go hand-in-hand with a more organization focus to address the problem.

Participative design

My investigation at Welldon also compels me to question the current emphasis on participatory design in the IS world. User participation has often been argued to be an essential ingredient of successful design projects because of its ability to facilitate improved communication and lowered resistance (Mumford 1997). However, the research on participative design has shown more erratic results with some systems failing despite significant user participation (Franz and Robey 1984). Several researchers have proposed explanations for this, including insufficient user involvement and influence (Howcroft and Wilson 2003) and weak leadership (Hirschheim 1985). All these explanations suggest that despite the controversial results around participative design, there is a strong belief among researchers that participation, if done right, is beneficial for design outcomes (for an exception see Wagner and Newell 2007).

The design process at Welldon was highly participative, with users, designers, and administrators all being very engaged in design. In fact, the idea of all the design committees was to have as much representation from different user groups as possible. Most design features were only incorporated after they were thoroughly discussed with the aid of design documents and screen prototypes, and voted upon by a "quorum" of users. Several conflicts occurred during the process, but the discussions were aimed at resolving these conflicts through changes in design. In that sense, the participative process at Welldon would be considered by many to be ideal. Yet the design did not produce the desired database. In fact the ideal participation may have contributed to the problems in the design process by: (1) causing significant delays during the design; (2) generating an increased expression of fears and desires; and (3) enhancing the intensity of both the fears and the desires.

Participation is time-consuming. At Welldon, every design decision went through multiple individuals and forums before it could be settled. Yet it was very easy to re-open issues for debate, even once decisions had been made. As a result, several adjustments had to be made to the project schedule to accommodate the changes. Eventually with the increasingly frequent changes, the IT office decided to introduce a formal change request process where change requests needed to be approved by the head of the EHS office as well as the project manager of the IT team. Delays, as seen at Welldon, are inevitable in participative designs but delays are argued to be offset by the benefits of better implementation (Hirschheim 1985).

However, the increased participation at Welldon did not necessarily create a better implementation given that the database did not meet its original goals. The delays in the process due to participation were thus arguably not fruitful. It is difficult to say whether the design would have been any better without all the participation. Reduced participation may have generated even a less satisfactory system. But the overzealous participation at Welldon caused its own set of problems more severe than just the delays, and if anything, contributed to the database departing from its objectives. This occurred because the increased participation surfaced a high number of highly intense, fears and desires.

With increased participation, users could evaluate the design from several perspectives. Moreover, users had a long time to digest a design element given the diverse forums that the designers used to discuss the same design elements. These in-depth and prolonged discussions were useful in generating several insights about the practices at the labs. For example the designers could get a better sense of the diverse inspection practices at the lab. However, the prolonged discussions also increased the fears and desires expressed by the users. Features such as default options would perhaps have been readily accepted but for the significant discussions. Default options were initially much desired at Welldon since they were meant to ease the data entry demands. But once people thought about them enough, they started raising concerns about the possibilities of inaccuracies in calculating the proportion of violations. Such fears were expressed later in the design process once people had analyzed the default options from every angle.

Even the intensity of the fears and desires increased with increased participation. It only took a handful of people to express their fears or desires, and emotions quickly gained momentum across a much wider body of users. For example, the fears against consequences were not as intense at the beginning of the design phase but as some people voiced their concerns, others caught on and the issue became big enough to cause the formation of a special committee just to assess the proposal on documenting consequences. Even desires seemed much stronger when people expressed them collectively. Desire for PDAs was hardly ever expressed at the beginning of the design discussions but once someone raised the issue in a joint meeting, all the floodgates opened with long discussions about PDAs occurring for weeks after that.

Besides delaying the design process, the increased number and intensity of the fears and desires had some other repercussions for the design outcomes. First, given that the trade-offs across the fears and desires made it almost impossible to satisfy every fear and desire, it left a general sense of dissatisfaction among the users. Users could never quite be completely satisfied. Second, and more importantly, the increased number and intensity of the fears and desires, and the designers' attempts to satisfy these fears and desires also enhanced the contradictions discussed earlier in this work, making it increasingly difficult to satisfy the goals of the database system. As designers made changes to satisfy some users, they created ripple effects in other parts of the system, making the design increasingly complex and dynamic.

As argued elsewhere in this work, during the design phase, users have not yet handled the artifact, causing them to speculate about the uses that they and the others would have for the artifact. Wagner and Newell (2007) in their examination of an ES implementation at a university found that the users in the early design phases found it very difficult to think beyond their traditional routines and anticipate the transformative potential of the ES artifact. During the design phase, a database is viewed through the lens of these traditional practices, making the concerns about the artifact largely speculative. Such speculative analysis of the artifact creates fears and desires that are not always realized during use. As people use the artifact and find other mechanisms and workarounds to accomplish their interests, they realize that some of the fears and desires may have been unfounded, or may have been different from those actually experienced. It is possible that the fears and desires that surface as people experience the database are much more intense and even more contradictory than what they perceived during design. However, attempts to address every fear and desire during the design phase, as done in the extremely participative process of Welldon, may not only cause delays but also intensify the contradictions experienced in design – contradictions that may be different from what people eventually experience with the system-in-use.

My investigation at Welldon has thus made me question accepted beliefs about participative design. The participation at Welldon did generate several insights about user practices. Moreover, despite some dissatisfaction among the users, it also created sufficient momentum and enthusiasm among them that they were familiar with the functionalities at the time of rollout. But the extreme participation also led to some detrimental effects. Wagner and Newell (2007) argue that ES systems are complex, making it difficult for changes to be made at least during the initial design phase. Moreover, users are still thinking in terms of their legacy systems, and are not motivated enough to contribute to the design when they have not actually engaged with the artifact through their routine practices. Wagner and Newell thus argue for an increased emphasis on post-implementation participation when users are more familiar with the system. My observations at Welldon, although slightly different from those of Wagner and Newell, lead me to make similar suggestions about participative design. Welldon would perhaps have benefited from a reduced emphasis on participation during the design phase and increased involvement after the rollout of the database. Such a process would have reduced the contradictions as well as the delays during the design, and would have allowed the changes to be made once users had more perspective on their own interaction with the database system.

In fact, given how much adaptation is typically required as people start using the artifact, it may also be useful to blur the lines between design and use. Such a boundary imposes a perception that the artifact has to be perfect before it is introduced for use. However, trying to perfect the artifact too early in its lifecycle increases the possibilities of the flights of fancy as seen in the case of Welldon. A more fluid conception of the technological artifact may create more room for prototyping and allow changes that are desired because of *experienced* constraints rather than *imagined* ones. It is difficult, however, to decide where to draw the line between stability and fluidity. It is a question for future research on what the implications are of introducing too malleable an artifact into the work practices – there is a risk of the artifact being rejected if it is introduced too early into use. But the case at Welldon shows the risks of being at the other extreme and of being overly-participative. Indeed, it may have been a case of too many cooks spoiling the broth.

Implications for risk management and compliance

The database system at Welldon was meant to enhance safety at Welldon. And yet, despite an enthusiastic attitude among various participants about achieving this goal, it fell short in many respects. How then do we manage the modern organization that is increasingly more loosely coupled, and spans geographical and legal boundaries? These organizations rely on ambitious technical systems, which the regulatory authorities rely on, along with other systems, to manage, flag, and monitor risks. Not all these systems are based entirely on information technology, but they are, nevertheless, typically based on some formal learning systems. For instance Leveson et al. (2004) describe the accident prevention system in Air force:

> In the traditional aircraft fly-fix-fly approach, investigations are conducted to reconstruct the causes of accidents, action is taken to prevent or minimize the recurrence of accidents with the same cause, and eventually these preventive actions are incorporated into standards, codes of practice, and regulations.

While such systems seem very effective on paper, my investigation at Welldon suggests that organizational actors have several trade-offs to consider, that formal systems are rarely able to meet. Moreover, systems are rarely designed just to maintain and establish accountability. They are often combined with other organizational goals to create highly stretched and compromised capacities. Even when systems are designed just to satisfy regulatory demands, it is difficult to have them recognize non-compliance *and* demonstrate compliance. Organizations will create systems that would portray them advantageously, but at the risk of forgoing internal governance. Finally, the systems that could facilitate regulation in one unit may not serve the needs of the diverse, other units.

Several scholars have suggested the need to have redundant systems in order to manage risk, and to ensure compliance (Morone and Woodhouse 1986; Sagan 1993). These redundancies need not always be in the form of formal systems, but could and should take the form of several other mechanisms. Jerome Lederer, the former director of NASA Manned Flight Safety Program for Apollo wrote (Lederer 1986):

> System safety covers the total spectrum of risk management. It goes *beyond the hardware* and associated procedures of system safety engineering. It involves: attitudes and motivation of designers and production people, employee/management rapport, the relation of industrial associations among themselves and with government, human factors in supervision and quality control, documentation on the interfaces of industrial and public safety with design and operations, the interest and attitudes of top management, the effects of the legal system on accident investigations and exchange of information, the certification of critical workers, political considerations, resources, public sentiment and many other non-technical but vital influences on the attainment of an acceptable level of risk control. These non-technical aspects of system safety cannot be ignored.

Scholars like Perrow (1999) adopt a much more pessimistic view about these redundant systems, and in fact, argue that these redundant systems could cause greater complacence about risk management. My study at Welldon contributes to this rather pessimistic picture of organizational risk and compliance, even in the highly regulated world of today with strong regulations like those required by Sarbanes Oxley. Systems are inevitably contradictory and the database at Welldon is yet another example in a world full of complex, contradictory, and fallible systems.

Applying the Welldon case

What I studied is a very specific case of database design in a specific organization. So can I generalize my findings? Walsham (1995) suggests different ways to assess generalizability of interpretive research -- in the form of concepts, theories, specific implications, or rich insights. "Interpretive researchers are not so interested in "falsifying" theories as in using theory more as a "sensitizing device" to view the world in a certain way" (Klein and Myers 1999, p.75).

I want to use my work at Welldon to sensitize existing research to the concept of contradictions – within individuals as well as across groups. While researchers have talked about the contradictions and paradoxes evident in organizations (Poole and van de Ven 1989; Robey and Boudreau 1999), we still attempt to create systems that would do away with all such conflicts and tensions. On the other hand, the database at Welldon shows that contradictions are inevitably present in most systems, especially those large one-size-fits-all-integrated systems. Systems are both products and constituents of complex and competing interests. The multiple interests lead to the desire for developing the systems that we hope would help us deal with the different interests. Without multiple interests, it would be almost meaningless to create systems. Yet the interests rarely converge. In fact the system design exercise generates further interests, redefines others, and surfaces the contradictions even more starkly. Moreover, the contradictions are inevitable even if we were to build systems just for ourselves. I see this even in the relatively simple systems that exist on my computer – I am constantly trying to juggle between trying to keep my Endnote library of citations comprehensive as well as efficient. Keeping all my citations in one library makes it easy to access citation sources but then I am unable to sort things by subject.[26]

While the concept of contradictions is applicable on a large scale, the process of contradictions and negotiations seen at Welldon would perhaps be much more applicable in systems that are created in professional bureaucracies. These systems would see a similar level of participation as at Welldon, and a similar way of negotiating these contradictions. At Welldon, issues were never quite closed. People could argue ad

[26] The Endnote software does allow some cataloging within an existing library but it never quite serves the specific purpose adequately.

nauseum about issues that concerned them and there was little pushback from anyone. Such an open design management is likely to result in greater surfacing of highly intense and difficult to resolve contradictions. In a more authoritative management style, perhaps someone makes the decision early in the discussions before too many contradictions surface. This of course does not do away with the contradictions that may yet emerge as people start using the system. But the nature of iterative negotiation seen at Welldon would perhaps not be visible in a more closed system design processes.

Another factor that contributed to the generation of contradictions at Welldon was the presence of both internal and external audiences for the database system. The Welldon designers were trying to balance the needs of both internal actors like the coordinators and the researchers and the regulatory bodies like the EPA. Similar systems are created in several organizations that are trying to follow the corporate regulations for risk management or financial disclosure while still satisfying some internal goals. In such systems, the contradictions are magnified because they exist not only across multiple interests but also across the diverse audiences. For example, the organizational need to demonstrate compliance would contradict with its need to manage itself internally.

My conversations with several IT managers have led me to believe that contradictions are largely present in all IS design and arguably across systems design. Yet, most writings on IT design would still make us believe that there exists a best way to design a system or that human failures cause the limitations in systems that we see. The investigation at Welldon shows that systems fall short of their goals not just because of human limitations but because of inherent contradictions that are very difficult to resolve and that can actually be amplified with greater attention and effort. The concept of contradictions needs to be incorporated in theories of system design, especially those that deal with systems of the kinds that I have described above.

Limitations and future research

The database design process at Welldon provided me with an opportunity to deeply examine the interactions around the artifact. Yet, Welldon is just one case of database design. While it allows me to draw parallels with design processes in other organizations, it also invites further investigation into different kinds of conditions that may reinforce my findings, or diverge from them.

The significant participation seen at Welldon, with little pushback from authorities, may be an aspect peculiar to professional bureaucracies. Several organizations do not have sufficient time to adopt the implementation of a systems project. These organizations undertake swift and often hierarchical decisions to get the design process moving. An exploration of the design process in organizations with different management styles could shed additional light on the merits and limitations of participative design. It would be interesting to see whether design looks as iterative in such a situation, and what the implications are for the usefulness of the system.

Another significant aspect of the Welldon case was the legal mandate whose implied threat of enforcement brokered several design discussions. Often, when negotiations were in danger of reaching a stalemate, an appeal was made to a regulatory need for the design to be a certain way. However, several organizations undertake software projects not because of an external threat but because of less clearly defined, internal organizational needs. In such a setting, it would be interesting to observe whether the absence of an external catalyst is a detriment or an enabler in the negotiation process.

Further work is also needed to examine less integrated systems. Perhaps such systems are more capable of satisfying their goals, given that they are trying to satisfy less diverse constituents, and they may manifest fewer contradictions among actors' fears and the desires.

Finally, the most significant limitation of my work is that it doesn't examine the actual use of the database system. This makes me unable to comment on how the fears and desires were realized or managed as people understood the implications of the database in practice. The lack of observations on use also makes it difficult to say how much the system strayed from its original goals. Perhaps, with sufficient workarounds and iterations after use, the system is able to come closer to its original goals or may become more useful.

Allowing for longer time-frames in the longitudinal examination of system design and use, and observations across other settings and other kinds of systems, would shed greater light on how systems are both so compromised and yet so ubiquitous.

References

2007. "Army urged dead soldiers to return to duty." in *Chicago Sun-Times.*

Akrich, M. 1992. "The De-scription of Technical Artifacts." Pp. 205-224 in *Shaping technology/building society : studies in sociotechnical change,* edited by J. Law. Cambridge, Mass.: MIT Press.

Arnold, M. 2003. "Systems design meets Habermas, Foucault and Latour." *Socio-technical and human cognition elements of information systems table of contents*:226-248.

Bain, P and P Taylor. 2000. "Entrapped by the'electronic panopticon'? Worker resistance in the call centre." *New Technology Work and Employment* 15:2-18.

Balderston, FE. 1995. *Managing Today's University: Strategies for Viability, Change, and Excellence*: Jossey-Bass.

Barker, James R. 1993. "Tightening the Iron Cage: Concertive Control in Self-Managing Teams." *Administrative Science Quarterly* 38:408-437.

Barki, Henri and Jon Hartwick. 1994. "User Participation, Conflict, and Conflict Resolution: The Mediating Roles of Influence." *Information Systems Research* 5:422-438.

Beath, Cynthia Mathis and Wanda J Orlikowski. 1994. "The contradictory structure of systems development methodologies: Deconstructing the IS-user relationship in Information Engineering." Pp. 350-377 in *Information Systems Research.* Linthicum.

Bechky, BA. 2003a. "Object Lessons: Workplace Artifacts as Representations of Occupational Jurisdiction." *AJS* 109:720-52.

—. 2003b. "Sharing Meaning Across Occupational Communities: The Transformation of Understanding on a Production Floor." *Organization Science* 14:312-330.

Beckman, HB and RM Frankel. 1984. "The effect of physician behavior on the collection of data." *Ann Intern Med* 101:692-6.

Berg, M. 1999. "Accumulating and Coordinating: Occasions for Information Technologies in Medical Work." *Computer Supported Cooperative Work (CSCW)* 8:373-401.

Berg, Marc. 1997. "Of forms, containers, and the electronic medical record: Some tools for a sociology of the formal." *Science, Technology & Human Values* 22:403-433.

—. 1998. "The politics of technology: On bringing social theory in technological design." *Science, Technology & Human Values* 23:456-490.

Berg, Marc and Geoffrey C Bowker. 1997. "The Multiple Bodies of the Medical Record: Toward a Sociology of an Artifact." *The Sociological Quarterly* 38:513.

Bloomfield, BP and R Coombs. 1990. *Information Technology, Control & Power: The Centralisation & Decentralisation Debate Revisited*: Manchester School of Management.

Bloomfield, BP and Ardha Danieli. 1995. "The Role of Management Consultants in the Development of Information Technology: The Indissoluble Nature of Socio-political and Technical Skills." *Journal of Management Studies* 32:47.

Bloomfield, Brian P and Theo Vurdubakis. 1997. "Visions Of Organization And Organizations Of Vision: The Representational Practices Of Information Systems Development." *Accounting, Organizations and Society* 22:639-668.

Bloomfield, Brian P. 1991. "The Role of Information Systems in the UK National Health Service: Action at a Distance and the Fetish of Calculation." *Social Studies of Science* 21:701-734.

Bogdan, R. 1976. "National Policy and Situated Meaning: The Case of Head Start and the Handicapped." *American Journal of Orthopsychiatry* 46:229-35.

Boland, RJ. 1978. "The Process and Product of System Design." *Management Science* 24:887-898.

Bossen, C. 2006. "Representations at work: a national standard for electronic health records." *Proceedings of the 2006 20th anniversary conference on Computer supported cooperative work*:69-78.

Boudreau, Marie Claude and Daniel Robey. 2005. "Enacting Integrated Information Technology: A Human Agency Perspective." *Organization Science*:3-18.

Bowker, Geoffrey C. and Susan Leigh Star. 1999. *Sorting things out : classification and its consequences*. Cambridge, Mass.: MIT Press.

Bradshaw-Camball, P and VV Murray. 1991. "Illusions and Other Games: A Trifocal View of Organizational Politics." *Organization Science* 2:379-398.

Cameron, KS. 1986. "Effectiveness As Paradox: Consensus and Conflict in Conceptions of Organizational Effectiveness." *Management Science* 32:539-553.

Carlile, PR. 2002. "A Pragmatic View of Knowledge and Boundaries: Boundary Objects in New Product Development." *Organization Science* 13:442-455.

Child, J. 1984. *Organization: A Guide to Problems and Practice*: Sage Publications.

Cochran, Nancy, Andrew C. Gordon, and Merton S. Krause. 1980. "Proactive Records: Reflections on the Village Watchman." *Knowledge: Creation, Diffusion, Utilization* 2:5-18.

Connell, H. 2004. *University Research Management: Meeting the Institutional Challenge*: Organisation for Economic Co-operation and Development.

Cunha, José João Marques de Oliveria Vieira da. 2006. "Making the numbers : agency in computer-generated formal representations of sales work." Massachusetts Institute of Technology. Unpublished dissertation.

Dalton, M. 1959. *Men who Manage: Fusions of Feeling and Theory in Administration*: Wiley.

Darke, P. and G. Shanks. 1997. "User viewpoint modelling: understanding and representing user viewpoints during requirements definition." *Information Systems Journal* 7:213-219.

Davenport, Thomas H. 1998. "Putting the enterprise into the enterprise system." *Harvard Business Review* 76:121-131.

Desrosieres, A. 1991. "How to Make Things which Hold Together: Social Science, Stnatistics and the State." *Discourses on Society: The Shaping of the Social Science Disciplines*.

Desrosieres, Alain. 2001. "How Real Are Statistics? Four Possible Attitudes." *Social Research* 68:339.

DiMaggio, Paul. 2001. *The twenty-first-century firm : changing economic organization in international perspective*. Princeton: Princeton University Press.

Elmes, Michael B., Diane M. Strong, and Olga Volkoff. 2005. "Panoptic empowerment and reflective conformity in enterprise systems-enabled organizations." *Information and Organization* 15:1-37.

Espeland, Wendy Nelson and Mitchell L. Stevens. 1998. "Commensuration as a Social Process." *Annual Review of Sociology* 24:313-343.

Ewick, Patricia and Susan S. Silbey. 1998. *The common place of law : stories from everyday life*. Chicago: University of Chicago Press.

Foucault, M. 1979. *Discipline and Punish: The Birth of the Prison*: Penguin.

—. 1980. *The History of Sexuality, Volume I: An Introduction*: Vintage Books.

—. 2001. "Truth and Power." in *Orientalism: A Reader*: New York University Press.

Foucault, M and C Gordon. 1980. *Power/knowledge: Selected Interviews and Other Writings, 1972-1977*: Pantheon Books.

Franz, CR and D Robey. 1984. "An investigation of user-led system design: rational and political perspectives." *Communications of the ACM* 27:1202-1209.

Friedman, AL and DS Cornford. 1989. *Computer Systems Development: History Organization and Implementation*: John Wiley & Sons, Inc. New York, NY, USA.

Gallivan, Michael J. and Mark Keil. 2003. "The user-developer communication process: a critical case study." *Information Systems Journal* 13:37-68.

Garfinkel, Harold. 1967. *Studies in ethnomethodology*. Englewood Cliffs, N.J.,: Prentice-Hall.

Gasser, Les. 1986. "The Integration of Computing and Routine Work." *ACM Transactions on Office Information Systems* 4:205-225.

Giddens, A. 1984. "The Constitution of Society: Outline of the Theory of Structure." University of California Press, Berkeley, CA.

Glaser, Barney G. and Anselm L. Strauss. 1967. *The discovery of grounded theory; strategies for qualitative research*. Chicago,: Aldine Pub. Co.

Goffman, E. 1967. "Interaction ritual: Essays onface-to-face behavior." New York: Pantheon.

Goffman, Erving. 1959. *The presentation of self in everyday life*. Garden City, N.Y.,: Doubleday.

Goodhue, DL, MD Wybo, and LJ Kirsch. 1992. "The Impact of Data Integration on the Costs and Benefits of Information Systems." *MIS Quarterly* 16:293-311.

Gosain, Sanjay. 2004. "Enterprise Information Systems as Objects and Carriers of Institutional Forces: The New Iron Cage?" Pp. 151-182 in *Journal of the Association for Information Systems*, vol. 5: Association for Information Systems.

Greenberg, J. 1987. "A Taxonomy of Organizational Justice Theories." *The Academy of Management Review* 12:9-22.

Grint, Keith and Steve Woolgar. 1997. *The machine at work : technology, work, and organization*. Cambridge, UK, Malden, MA: Polity Press ; Published in the USA by Blackwell.

Grojer, Jan-Erik. 2001. "Intangibles and accounting classifications: in search of a classification strategy." *Accounting,Organizations and Society* 26:695-713.

Hacking, I. 1986. "Making up People." Pp. xiv, 365 in *Reconstructing individualism : autonomy, individuality, and the self in Western thought*, edited by T. C. Heller and C. Brooke-Rose. Stanford, Calif.: Stanford University Press.

Hackman, JR and RE Kaplan. 1974. "Interventions into group process: An approach to improving the effectiveness of groups." *Decision Sciences* 5:459-480.

Hammer, M and S Stanton. 1999. "How process enterprises really work." *Harvard Business Review* 77:108-118.

Hartwick, Jon and Henri Barki. 1994. "Explaining the Role of User Participation in Information System Use." *Management Science* 40:440-465.

Heath, C and P Luff. 1996. "Documents and professional practice:"bad" organisational reasons for "good" clinical records." *Proceedings of the 1996 ACM conference on Computer supported cooperative work*:354-363.

Henderson, K. 1991. "Flexible Sketches and Inflexible Data Bases: Visual Communication, Conscription Devices, and Boundary Objects in Design Engineering." *Science, Technology & Human Values* 16:448.

Heracleous, L and M Barrett. 2001. "Organizational Change as Discourse: Communicative Actions and Deep Structures in the Context of Information Technology Implementation." *The Academy of Management Journal* 44:755-778.

Hirschheim, R and M Newman. 1988. "Information Systems and User Resistance: Theory and Practice." *The Computer Journal* 31:398.

—. 1991. "Symbolism and information systems development: myth, metaphor and magic." *Information Systems Research* 2:29-62.

Hirschheim, RA. 1985. "User Experience with and Assessment of Participative Systems Design." *MIS Quarterly* 9:295-304.

Hollinger, RC and JP Clark. 1982. "Formal and Informal Social Controls of Employee Deviance." *The Sociological Quarterly* 23:333-343.

Howcroft, D and M Wilson. 2003. "Paradoxes of participatory practices: the Janus role of the systems developer." *Information and Organization* 13:1-24.

Introna, Lucas D. and Helen Nissenbaum. 2000. "Shaping the Web: Why the Politics of Search Engines Matters." *Information Society* 16:169-185.

Ives, Blake and Margrethe H. Olson. 1984. "User Involvement and MIS Success: A Review of Research." *Management Science* 30:586-603.

Jasperson, J, TA Carte, CS Saunders, BS Butler, HJP Croes, and W Zheng. 2002. "Review: Power and Information Technology Research: A Metatriangulation Review." *MIS Quarterly* 26:397-459.

Kandel, E and EP Lazear. 1992. "Peer Pressure and Partnerships." *The Journal of Political Economy* 100:801-817.

Kaplan, RS and DP Norton. 1996. "Using the balanced scorecard as a strategic management system." *Harvard Business Review* 74:75-85.

Kerr, S. 1975. "On the Folly of Rewarding A, While Hoping for B." *The Academy of Management Journal* 18:769-783.

Kirsch, L.J. and C.M. Beath. 1996. "The enactments and consequences of token, shared, and compliant participation in information systems development." *Accounting, Management and Information Technologies* 6.

Klein, HK and MD Myers. 1999. "A Set of Principles for Conducting and Evaluating Interpretive Field Studies in Information Systems." *MIS Quarterly* 23:67-93.

Kling, R. 1991. "Computerization and Social Transformations." *Science, Technology & Human Values* 16:342.

Knights, David and Fergus Murray. 1994. *Managers divided : organisation politics and information technology management.* Chichester England ; New York: J. Wiley.

Knorr-Cetina, K. 1999. *Epistemic cultures : how the sciences make knowledge.* Cambridge, Mass.: Harvard University Press.

Kraut, RE. 1976. "Deterrent and Definitional Influences on Shoplifting." *Social Problems* 23:358-368.

Lapointe, L and S Rivard. 2007. "A Triple Take on Information System Implementation." *Organization Science* 18:89-107.

Lasswell, HD. 1950. *Politics: Who Gets What, When, how*: P. Smith.

Latour, Bruno. 1987. *Science in action : how to follow scientists and engineers through society.* Cambridge, Mass.: Harvard University Press.

—. 1992. "Where Are the Missing Masses? The Sociology of a Few Mundane Artifacts." in *Shaping Technology/Building Society: Studies in Sociotechnical Change*, edited by J. Law: MIT Press.

Laughlin, Richard. 1996. "Principals and higher principals." Pp. 225-244 in *Accountability : power, ethos and the technologies of managing*, edited by R. Munro and J. Mouritsen. London ; Boston: International Thomson Business Press.

Lederer, Jerome. 1986. "How far have we come? A look back at the leading edge of system safety eighteen years ago." *Hazard Prevention*:8-10.

Lee, JC and MD Myers. 2004. "Dominant actors, political agendas, and strategic shifts over time: a critical ethnography of an enterprise systems implementation." *Journal of Strategic Information Systems* 13:355–374.

Lemert, E.M. 1969. "Records in the Juvenile Court." Pp. 355-388 in *On record: files and dossiers in American life*, edited by S. Wheeler. New York: Russell Sage Foundation.

Leventhal, GS. 1976. "What Should Be Done with Equity Theory? New Approaches to the Study of Fairness in Social Relationships."

Leveson, Nancy, Joel Cutcher-Gershenfeld, Betty Barrett, Alexander Brown, John Carroll, Nicolas Dulac, Lydia Fraile, and Karen Marais. 2004. "Effectively Addressing NASA's Organizational and Safety Culture: Insights from Systems Safety and Engineering Systems." Massachusetts Institute of Technology, Cambridge MA.

Lilley, Simon. 1996. "Refining accountabilities: opening the black box of management systems success." Pp. 118-143 in *Accountability : power, ethos and the technologies of managing*, edited by J. Mouritsen. London ; Boston: International Thomson Business Press.

Litwin, Adam Seth. 2008. "Information Technology & the Employment Relationship." Massachusetts Institute of Technology. Unpublished dissertation.

Lucas, HC. 1975. *Why Information Systems Fail*: Columbia University Press.

Mackay, Hugh, Chris Carne, Paul Beynon-Davies, and Doug Tudhope. 2000. "Reconfiguring the User: Using Rapid Application Development." *Social Studies of Science* 30:737-757.

Markus, M. Lynne, Sheryl Axline, David Petrie, and Sheryl Cornelis Tanis. 2000. "Learning from adopters' experiences with ERP: problems encountered and success achieved." *Journal of Information Technology* 15:245-265.

Markus, M. Lynne and Niels Bjorn-Andersen. 1987. "Power over users: its exercise by system professionals." *Commun. ACM* 30:498-504.

Markus, ML. 1983. "Power, politics, and MIS implementation." *Communications of the ACM* 26:430-444.

—. 2001. "Toward a Theory of Knowledge Reuse: Types of Knowledge Reuse Situations and Factors in Reuse Success." *Journal of Management Information Systems* 18:57-93.

Mazmanian, MA, WJ Orlikowski, and J Yates. 2005. "Crackberries: the social implications of ubiquitous wireless e-mail devices." Pp. 337–344 in *Designing Ubiquitous Information Environments: Socio-Technical Issues and Challenges*, edited by C. Sørensen, Y. Yoo, K. Lyytinen, and J. DeGross: Springer.

Mccleary, R. 1977. "How Parole Officers Use Records." *Social Problems* 24:576-589.

McKemmish, Sue and Frank Upward. 1993. *Archival documents : providing accountability through recordkeeping*. Melbourne: Ancora Press.

Miller, P. 1992. "Accounting and Objectivity: The Invention of Calculating Selves and Calculable Spaces." *Annals of Scholarship* 9.

—. 1994. "Accounting as social and institutional practice: an Introduction." Pp. 1-39 in *Accounting as social and institutional practice*, edited by A. G. Hopwood and P. Miller. Cambridge England ; New York: Cambridge University Press.

—. 2001. "Governing by Numbers: Why Calculative Practices Matter." *Social Research* 68:379.

Mintzberg, Henry. 1979. *The structuring of organizations : a synthesis of the research*. Englewood Cliffs, N.J.: Prentice-Hall.

Monteiro, E and O Hanseth. 1996. "Social shaping of information infrastructure: on being specific about the technology." Pp. 325–43 in *Information Technology and Changes in Organizational Work*, edited by W. Orlikowski, G. Walsham, M. Jones, and J. I. DeGross: Chapman & Hall.

Morone, JG and EJ Woodhouse. 1986. *Averting Catastrophe: Strategies for Regulating Risky Technologies*: University of California Press, Berkeley, CA.

Mumford, E. 1997. "The reality of participative systems design: contributing to stability in a rocking boat." *Information Systems Journal* 7:309-322.

Myers, MD and Leslie W Young. 1997. "Hidden agendas, power and managerial assumptions in information systems development: An ethnographic study." *Information Technology & People* 10:224-240.

Newman, Michael and Faith Noble. 1990. "User Involvement as an Interaction Process: A Case Study." *Information Systems Research* 1:89-113.

Orlikowski, Wanda J. 1991. "Integrated Information Environment or Matrix of Control?: The Contradictory Implications of Information Technology." *Accounting, Management, and Information Technologies* 1.

—. 1992. "The Duality of Technology: Rethinking the Concept of Technology in Organizations." *Organization Science* 3:398-427.

—. 2002. "Knowing in practice: Enacting a collective capability in distributed organizing." Pp. 249-273 25 pages. in *Organization Science*. Linthicum.

—. 2006. "Material Knowing: The Scaffolding of Human Knowledgeability." *European Journal of Information Systems* 15:460.

Orlikowski, WJ and J Yates. 1994. "Genre Repertoire: The Structuring of Communicative Practices in Organizations." *Administrative Science Quarterly* 39.

Pentland, Brian T. and Paul Carlile. 1996. "Audit the taxpayer, not the return: Tax auditing as an expression game." *Accounting, Organizations and Society* 21:269-287.

Perrow, C. 1999. "Normal Accidents: living with high-risk technologies."

Pfeffer, J and WL Moore. 1980. "Power in University Budgeting: A Replication and Extension." *Administrative Science Quarterly* 25:637-653.

Pollock, Neil. 2005. "When Is a Work-Around? Conflict and Negotiation in Computer Systems Development." *Science Technology Human Values* 30:496-514.

Poole, MS and AH van de Ven. 1989. "Using Paradox to Build Management and Organization Theories." *The Academy of Management Review* 14:562-578.

Porter, Theodore M. 1992. "Objectivity as standardization: The rhetoric of impersonality in measurement, statistics, and cost-benefit analysis." *Annals of Scholarship.*

Power, Michael. 1996. "Making things auditable." *Accounting, Organizations and Society* 21:289-315.

Rawls, J. 2005. *Political Liberalism*: Columbia University Press.

Ridgway, VF. 1956. "Dysfunctional Consequences of Performance Measurements." *Administrative Science Quarterly* 1:240-247.

Roberts, J. 1991. "The Possibilities of Accountability." *Accounting, Organizations and Society* 16:355-368.

Robey, D and MC Boudreau. 1999. "Accounting for the contradictory organizational consequences of information technology: Theoretical directions and methodological implications." *Information Systems Research* 10:167-185.

Robey, D, DL Farrow, and CR Franz. 1989. "Group Process and Conflict in System Development." *Management Science* 35:1172-1191.

Robey, D, LA Smith, and LR Vijayasarathy. 1993. "Perceptions of conflict and success in information systems development projects." *Journal of Management Information Systems* 10:123-139.

Robey, Daniel and Dana Farrow. 1982. "User Involvement in Information System Development: A Conflict Model and Empirical Test." Pp. 73-85 in *Management Science.* Linthicum.

Robey, Daniel and M. Lynne Markus. 1984. "Rituals In Information System Design." *MIS Quarterly* 8:5-15.

Ross, JW and MR Vitale. 2000. "The ERP Revolution: Surviving vs. Thriving." *Information Systems Frontiers* 2:233-241.

Rule, James B., David Caplovitz, and Pierce Barker. 1969. "The Dossier in Consumer Credit." Pp. 143-176 in *On record: files and dossiers in American life*, edited by S. Wheeler. New York: Russell Sage Foundation.

Rule, James and Peter Brantley. 1992. "Computerized Surveillance in the Workplace: Forms and Distributions." *Sociological Forum* 7:405-423.

Rule, JB. 1973. *Private Lives and Public Surveillance [by] James B. Rule.-*: Allen Lane.

Sagan, SD. 1993. "The Limits of Safety: Organizations, Accidents, and Nuclear Weapons."

Sarker, S and AS Lee. 2003. "Using a case study to test the role of three key social enablers in ERP implementation." *Information & Management* 40:813-829.

Saunders, CS. 1981. "Management Information Systems, Communications, and Departmental Power: An Integrative Model." *The Academy of Management Review* 6:431-442.

Schultze, Ulrike and Wanda J. Orlikowski. 2004. "A Practice Perspective on Technology-Mediated Network Relations: The Use of Internet-Based Self-Serve Technologies." Pp. 87-106 in *Information Systems Research.* Linthicum.

Seidman, D and M Couzens. 1974. "Getting the Crime Rate Down: Political Pressure and Crime Reporting." *Law & Society Review* 8:457-494.

Selznick, P. 1949. "TVA and the Grass Roots (Berkeley and Los Angeles." University of California Press.

Selznick, P, P Nonet, and HM Vollmer. 1969. *Law, society, and industrial justice*: Russell Sage Foundation [New York.

Sewell, Graham. 1998. "The Discipline of Teams: The Control of Team-Based Industrial Work Through Electronic and Peer Surveillance." *Administrative Science Quarterly* 43:397-428.

Sia, Siew Kien, May Tang, Christina Soh, and Wai Fong Boh. 2002. "Enterprise resource planning (ERP) systems as a technology of power: Empowerment or panoptic control?" *Database for Advances in Information Systems* 33:23.

Silbey, Susan, Ruthanne Huising, and Salo Coslovsky. 2008. "The Sociological Citizen: Recognizing Relational Interdependence in Law and Organizations." *Annee Sociologique* (Forthcoming).

Sinclair, Amanda. 1995. "The chameleon of accountability: Forms and discourses." *Accounting, Organizations and Society* 20:219-237.

Smith, D. 1984. "Textually mediated social organization." *International Social Science Journal* 36:59-75.

Soh, Christina and Siew Kien Sia. 2004. "An institutional perspective on sources of ERP package-organisation misalignments." *The Journal of Strategic Information Systems* 13:375-397.

Star, SL and JR Griesemer. 1989. "Institutional Ecology,Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39." *Social Studies of Science* 19:387.

Star, Susan Leigh and Karen Ruhleder. 1996. "Steps Toward an Ecology of Infrastructure: Design and Access for Large Information Spaces." *Information Systems Research* 7:111.

Strauss, Anselm L. and Juliet M. Corbin. 1998. *Basics of qualitative research : techniques and procedures for developing grounded theory*. Thousand Oaks: Sage Publications.

Strauss, DA, Law School, and University of Chicago. 2002. *Must Like Cases be Treated Alike?*: Law School, the University of Chicago.

Suchman, LA. 1987. *Plans and Situated Actions: The Problem of Human-Machine Communication*: Cambridge University Press.

—. 1995. "Making work visible." *Communications of the ACM* 38.

Tan, BCY, KK Wei, RT Watson, DL Clapper, and ER McLean. 1998. "Computer-Mediated Communication and Majority Influence: Assessing the Impact in an Individualistic and a Collectivistic Culture." *Management Science* 44:1263-1278.

Thompson, P and C Smith. 2001. "Follow the redbrick road: Reflections on pathways in and out of the labor process debate." *International Studies of Management and Organization* 30:40-67.

Trace, CB. 2002. "What is Recorded is Never Simply What Happened': Record Keeping in Modern Organizational Culture." *Archival Science* 2:137-159.

Uzzi, B. 1996. "The Sources and Consequences of Embeddedness for the Economic Performance of Organizations: The Network Effect." *American Sociological Review* 61:674-698.

Van Maanen, J. and B. T. Pentland. 1994. "Cops and auditors: The rhetoric of records." Pp. 53-90 in *The legalistic organization*, edited by S. B. Sitkin and R. J. Bies: Newbury Park, CA: Sage.

Van Oost, E. 2003. "Materialized gender: how shavers configure the users' femininity and masculinity'." *How Users Matter: The Co-construction of Users and Technology, eds N. Oudshoorn & T. Pinch, MIT Press, Cambridge, MA*:193–208.

Wagner, Erica L and Sue Newell. 2007. "Exploring the Importance of Participation in the Post-Implementation Period of an ES Project: A Neglected Area." *Journal of the Association for Information Systems* 8:508.

Wagner, Erica L. and Sue Newell. 2004. "'Best' for whom?: the tension between 'best practice' ERP packages and diverse epistemic cultures in a university context." *The Journal of Strategic Information Systems* 13:305-328.

Walsham, G. 1995. "Interpretive case studies in IS research: nature and method." *European Journal of Information Systems* 4:74-81.

Weber, Max, Hans Heinrich Gerth, and C. Wright Mills. 1958. *From Max Weber: Essays in sociology*. New York,: Oxford University Press.

Weick, KE. 1979. *The social psychology of organizing*. Random House.

Wheeler, Stanton. 1969. *On record: files and dossiers in American life*. New York,: Russell Sage Foundation.

Wilmott, H. 1996. "Thinking accountability: accounting for the disciplined production of self." Pp. 23-39 in *Accountability : power, ethos and the technologies of managing*, edited by R. Munro and J. Mouritsen. London ; Boston: International Thomson Business Press.

Woolgar, S. 1991. "Configuring the user: the case of usability trials." *A Sociology of Monsters: Essays on Power, Technology and Domination*:58-97.

Yates, JoAnne. 1989. *Control through communication : the rise of system in American management*. Baltimore: Johns Hopkins University Press.

Zuboff, Shoshana. 1988. *In the age of the smart machine : the future of work and power*. New York: Basic Books.