INVESTIGATING RUPTURES IN SHARED UNDERSTANDING AS RECURSIVE CYCLES OF MUTUAL ADAPTATION DURING IMPLEMENTATION

Complete Research

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Abstract

Shared understanding between diverse technology stakeholders is a key driver of IT-Business alignment, also underpinning successful adaptive, IS development activities. Lack of shared understanding creates representational gaps, innovation blindness and different technology frames which create barriers to development and implementation of technology. Applying a socio-material perspective to Leonard-Barton's model of mutual adaptation between technology and organization, as well as research on shared capabilities between IS and business stakeholders, we examine the process by which shared understanding emerges during the design, development and implementation of IT systems. We followed key multi-disciplinary stakeholder groups over a two-year period during the development and implementation of a health information system. We report on events during the project that we call ruptures – highly charged incidents which reveal a lack shared understanding between stakeholders. We argue that ruptures occur during the mutual adaptation of organizational and technological elements necessitated by the implementation process and are precipitated by the constitutive entanglement of social and technological elements. They reveal serious misalignments among stakeholders and in relation to the technology as its material properties become more concrete. We investigate the emergence of ruptures and the mechanisms by which they influence stakeholders, the implementation process and its outcomes.

Keywords: Mutual Adaptation, Shared Cognition, Socio-materiality, IS Development & Implementation

1 Introduction

This study investigates the evolution of shared understanding among multi-disciplinary stakeholders engaged in a transformational IT-enabled organizational change effort. The presence of shared understanding between diverse stakeholders of a technology is a key driver of Business-IT alignment and it is seen as underpinning successful adaptive, IS development activities. A lack of shared understanding contributes to representational gaps (Cronin & Weingart, 2007), innovation blindness (Leonardi, 2011) and different technology frames (Wanda J. Orlikowski & Gash, 1994) which create barriers to the successful and effective development and implementation of technology.

While prior research has considered the need for and value of shared understanding amongst stakeholders during the design, development and implementation of IT, we lack insight into how such shared understanding emerges and evolves. This became our research objective. To shed light on the evolution of shared understanding during implementation, we turned to Leonard-Barton's model of mutual adaptation between technology and organization (Leonard-Barton, 1988). Applying a socio-

material perspective to this model (Leonardi & Barley, 2008), and incorporating the research on shared knowledge between business and IS stakeholders as drivers of IT value, we examine the process by which shared understanding emerges via mutual adaptation during the design, development and implementation of IT systems within a healthcare setting.

Below we outline the literature which informed our research. The role of shared understanding in alignment and value creation enabled us to situate the significance of our research question. Subsequently, we narrowed our focus to the information systems development (ISD) stage of implementation seeking insights from research on adaptive IS practices as well as the learning processes for stakeholders during ISD. Leonard-Barton's model of mutual adaptation served to inspire our theoretical development. However, in order to focus the model to support the investigation of shared understanding we integrated a socio-material lens to focus on the constitutively entangled elements (Orlikowski, 2007): the stakeholders (social) and the material properties of the technology which are implicated in this phenomenon.

Our methods were qualitative and grounded in interpreting multiple data sources from a longitudinal field study of the implementation of a transformational IT in a healthcare setting. In this study, we report on the design and development phase and our observation and interpretation of events that we call ruptures — highly charged incidents which spotlight the revelation of a lack shared understanding between stakeholders. We investigate the emergence of ruptures and the mechanisms by which ruptures precipitate recursive cycles of mutual adaptation that influence stakeholders, the implementation process and its outcomes.

2 Literature Review

Organizations spend enormous sums on IT (Iivari & Huisman, 2007), more than on all other forms of capital combined (Bureau of Economic Analysis, 2012). Historical success rates for IT projects are poor, but improving (Sauer, Gemino, & Reich, 2007). Yet firms struggle to realize value from their IT investments. A variety of reasons for this inability to realize business value from IT investments have been investigated including IT project management practices (Kirsch, 2000); firm level factors (Melville, Kraemer, & Gurbaxani, 2004; Piccoli & Ives, 2005) and business-IT alignment (Reich & Benbasat, 2000). Firms with effective IT governance earn up to 40% higher returns (Weill & Ross, 2004) which is achieved through mechanisms which promote the alignment of business and IT. Others have established that greater strategic alignment enhances firm performance (Y E Chan, Huff, Barclay, & Copeland, 1997; Sabherwal & Chan, 2001). Alignment is the process of matching the goals, objectives and strategies of the IT department with those of the firm (Campbell & Kay, 2005; Yolande E. Chan, 2002; Henderson & Venkatraman, 1996; Reich & Benbasat, 2000). Shared understanding amongst key stakeholders is critical to successful alignment practices and outcomes and it has been examined in multiple ways. When business and IT people have a common understanding of the other's technical knowledge (shared domain knowledge), they engage in more effective communication, create a more trusting relationship and ultimately realize greater value from investments (Campbell & Kay, 2005; Reich & Benbasat, 2000). Examining shared understanding as competencies, we know that business professionals need knowledge of technology, applications, systems development, and IT management, as well as knowledge about who to ask whereas IT professionals need to have knowledge of the organization and its processes, leadership, networking and communications skills (resulting in a higher intention to develop a partnership) (Bassellier, Benbasat, & Reich, 2003). Reich & Benbasat (2000) looked at the current practices (in addition to shared domain knowledge) that support alignment, including regular communication and connections between IT and business planning.

While a competency-based perspective sheds light on the observation that shared knowledge and understanding is an important factor – it does not provide us with insight into how shared knowledge develops. While it may represent an 'overlap' in knowledge we believe a more dynamic orientation

must be considered. If alignment is to be achieved, some level of knowledge sharing must occur in order to achieve shared knowledge. Since alignment is at least partly manifest in the way in which new IT is brought to bear on achieving firm strategy, we examined the literature on systems development and implementation for insight.

The information systems development (ISD) literature has sought to understand the practice of systems development within implementation research, the factors influencing ISD success and failure and provided numerous prescriptive practices to achieve success (Galliers & Swan, 2000; Lyytinen & Robey, 1999). Branches of ISD research have also investigated the success of iterative, adaptive methods over more traditional planned methods (Abrahamsson, Conboy, & Wang, 2009) the need for 'cultivation' approaches (Ciborra & Hanseth, 1998) over adhering to a pre-programmed plan and the recognition of implementation as a continuation of the innovation process – requiring mutual adaptation during implementation because 'technology almost never fits perfectly into the user environment' (Leonard-Barton, 1988, p.252). These latter approaches embed notion of learning as a critical task with ISD (Lyytinen & Robey, 1999; Robey, Ross, & Boudreau, 2002). They situate requirements analysis as a socially constructed task of discovering emergent requirements over time (Holmström & Sawyer, 2010) and accept pluralism and subjectivity as underpinning (Galliers & Swan, 2000), raising the implication that negotiating these emergent, subject and pluralistic needs amongst groups stakeholders is a crucial factor in ISD success. Thus it seems that social learning – i.e. shared knowledge and knowledge sharing must be processes in play during ISD.

But our review of this literature again suggests that while much effort has been put into understanding the socially constructed and learning dimensions of effective ISD efforts, findings have emphasized developers' needs and understandings over that of business stakeholders (Holmström & Sawyer, 2010) or accounted for knowledge deficiencies at a high level of aggregation such as configuration or assimilation knowledge barriers (Robey et al., 2002). Therefore, in studying the emergence and evolution of shared understanding for ISD, we sought a theoretical logic that would enable us to account for the emergent, subjective and pluralistic realities of the ISD process.

3 Theoretical Approach

Dorothy Leonard Barton's account of mutual adaptation during the implementation process of technology provides a strong theoretical basis for viewing the learning process and emergent nature of ISD (Leonard-Barton, 1988, p. 251). Reproduced here as Figure 1, it draws attention to both the user environment and the technology and the need for the mutual adaptation of one or both as new technology is implemented in an organization. Her work suggests a need to explore cycles of adaptation and presents cycles as both small and large – varying on the degree to which time and resources are required to bring misalignments into alignment. Both types of misalignments are explained and small and large technology cycles of adaptation, and organizational cycles of adaptation (based on performance criteria or delivery systems) are explored.

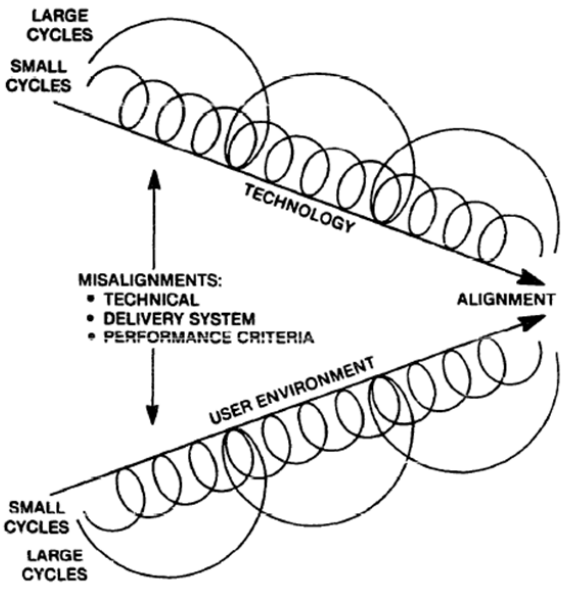

Fig. 1. Mutual adaptation of technology and organization.

However helpful this conception is, it was incomplete for our needs on two fronts. First, even as it accounts for mutual adaptation as the simultaneous adaptation of technology and organization together, it still holds these two facets of the phenom-

enon as discrete or ontologically separate. Thus it fails to account for more recent socio-material perspectives on technology in organizations which emphasizes the constitutive entanglement orientation towards the social and the material (Leonardi & Barley, 2008, 2010; W. J. Orlikowski, 2007).

Second, although it is intended to situate itself at multiple levels of an organization's mutual adaptation experience, it fails to explicate how shared understanding amongst stakeholders (within themselves, between each other) and about the material properties of the technology (as it moves from abstract to concrete artifact) emerges through social interactions and material interactions with the technology (Leonardi, 2011).

For theoretical insight on socio-materiality in IT implementation, we turned to the works of Wanda Orlikowski, Paul Leonardi and Stephen Barley. In order to take socio-materiality seriously as a theoretical lens we need to embrace constitutive entanglement of the social and the material. This requires re-thinking the separation of technology and the user environment depicted in Figure 1 above and instead conceiving of cycles of adaptation as occurring through a single, recursive cycle of human-material entanglements (Orlikowski, 2007) or the mangle of practice (Pickering, 1995).

Leonardi and Barley's work on technology and organizational change deploys socio-material theoretical techniques which help shed light on how social interactions shape peoples interpretation of technology, how they use them and how that use will either promote or stymie organizational change. He finds it is possible to understand why the organizational change failed by accounting for how the participants constructed information about the technology through both their social and material interactions with it (Leonardi & Barley, 2008). Given this insight, we determined that our research strategy to study the emergence of shared understanding would need to provide us with a longitudinal view that captured the emergent nature of the social interactions of stakeholders and their socio-material interactions with the technology artefact being developed. We described our approach next.

4 Research Methodology

In order to investigate the evolution of shared understanding, a longitudinal field study was required. We needed a longitudinal study to be able to see the evolution as it unfolded, rather than relying on retrospective accounts, which are known to be unreliable (Nisbett & Wilson, 1977). The depth of an intensive field study was necessary because the nature of shared understanding (how it is measured, what might influence it) is unknown. So a degree of emergence in the research was important. A case study was conducted using a variety of data sources.

4.1 Research Context

We studied a project called the *Clinical Transformation Project (CTP[1]).*CTP involved the implementation of new capabilities within the organization's EMR system, which was purchased from a leading vendor (hereafter referred to as the vendor). Four specific capabilities were being introduced: computerized provider order entry (CPOE), electronic medication reconciliation (e-Med Rec), electronic Medication Administration Record (eMAR) and closed loop medication administration (CLMA). These capabilities would radically change the work of most clinical staff at the hospitals. For example physicians would be required to enter medication, lab and diagnostic imaging orders directly into the computer system rather than writing them on paper and having the data entry done by non-regulated (i.e., clerical) personnel. The process by which nurses administered medications would also change, requiring a workstation on wheels (WOW) to transport medications and record their administration, and scanning of barcodes on the medication and the patient's wristband before each drug administra-

[1] A pseudonym.

tion. Because of the level of intended workflow change, and because the objectives of the project were related to improving quality of care, the project was officially positioned as a clinical transformation activity rather than an IT project.

Ten Canadian hospital organizations were involved in the project: 3 large teaching hospitals in an urban area and 7 regional hospitals spread throughout the surrounding community. The teaching hospitals reflected the typical referral sites for the regional hospitals. The EMR vendor was engaged as an implementation consultant, providing services related to system configuration and building as well as some assistance in project and change management.

The structure of the project was somewhat unique in that the hospital IT was managed through a shared service organization housed at one of the teaching hospitals (Hospital X). This shared services organization housed the project team for all 10 hospitals.

The project was first conceived in 2009, when a new CEO at one of the teaching hospitals (Hospital Y) promoted the changes based on experiences in a prior hospital. It was originally planned to be initiated in 2010 and completed in 2016 but was ultimately advanced due to its alignment with various other organizational initiatives and the availability of funding to support it. The project charter was formally approved in 2011, with implementations phased across the 10 hospitals from late 2013 to mid-2014. The project followed a largely sequential, structured design methodology based on the vendor's recommendation. Workflow sessions were conducted early on with potential users to both understand requirements and map the degree of change required. A design review was conducted early in the process to explain the system logic to the users. Following the workflow sessions and design review, a design team, composed of hospital and vendor personnel worked to configure the vendor software for the organization. Implementation was conducted in phases, with different hospitals going live over an eight month period.

4.2 Data Collection

The primary data for this project come from participant observation. We were able to attend meetings of the project steering committee and the joint advisory committee (including clinicians and physicians). Each of these groups met monthly, and our observation ran from November 2012 to the present time. During these meetings each member of the research team took separate notes creating 52 individual detailed documents of observations. We also observed two hospital-wide events involving hundreds of participants: a design review when the vendor presented the system functionality (November 2012) and a pre-implementation briefing day (in September 2013). One of us was also on site at many of the hospitals during the first few days after they went live. During these visits we observed the activities of project team members in the command centre. We were not able to observe out on the hospital floors due to the additional ethics requirements associated with having access to patients and patient data. However, discussions in the command centre focused directly on the experiences of users out on the floors and so we feel that we got at least a reasonable sense of how things were progressing. We also were able to do some informal observation during our lunch breaks, when we were in the hospital cafeterias.

In addition to participant observation, we were able to conduct 1 hour interviews with sixteen members of the joint advisory committee and steering committees, including the project sponsor, the executive sponsor, and the vendor's engagement manager. These interviews allowed us to probe further on the observations we were making, and learn more about the experiences of participants in the process. We had regular informal conversations with participants on the two committees we observed throughout the project. We also had access to hundreds of project documents, including the project charter, budgets, meeting minutes, the close-out report from the project sponsor, and a series of post-implementation reviews conducted by various internal and external parties. Finally, about 5 months after the final hospital go-live, as part of the project close-out activities we conducted an open-ended survey of 122 people who were involved in the project (from team leads, to the executive sponsor)

asking each person to identify the key lessons learned from the project in terms of governance, project management, benefits realization, stewardship of resources, communication, training and support,

4.3 Data Analysis & Findings

We used a subset of data for this research – specifically the data associated with the design and development activities and their impact; this was principally the observation data and interviews. As there were 10 organizations and each launched the system at separate times over an 8 month period design and development activities actually continued for later organizations, even though earlier organizations had launched the system.

Data analysis for this project is proceeding in an iterative fashion. When attending meetings, we both kept detailed field notes, recording the important conversations. We paid particular attention to parts of the discussion that pertained to the participants' understandings of the CTP, and of the technology that was central to achieving the organizational goals. We usually met following the meetings to discuss our different perspectives on what we had observed, and then reviewed and perhaps amended our notes based on the conversation. Our field notes and interviews were transcribed and entered into an NVivo database, along with all of the project documents we have obtained.

Coding of the NVivo data is being done by both authors as well as a research assistant, looking for common themes related to the development of shared understanding. In our earliest observations, we were able to observe instances where participants did not share a common understanding of the project. For example, we had been told in numerous discussions with the project sponsor and the VP of IT, that the naming of the project was critical in order to convey it as a clinical rather than IT project. So, the CTP name was meant to refer to the organizational change (including the technology) rather than to the system per se. But in the first steering committee meeting that we attended, we observed several instances of people referring to the system as CTP and then being corrected by others. Developing this shared language to ensure that the meaning of CTP was preserved to be the organizational change was a critical consideration. Over time, we observed less vigilance about correcting mis-uses of the term. Yet the idea of CTP as a clinical transformation rather than an IT implementation was maintained within this group. Other instances related to shared understanding also began to emerge from the data, and these are the focus of our findings. We call these instances "ruptures". Ruptures are points where the smooth progress of the project gets interrupted by an unexpected event or issue. They reflect the disagreements among stakeholders, but they are not the disagreements per se. Rather they are the points at which the disagreement becomes "visible" to the group.

We begin by describing 3 of these ruptures, and then we turn to our interpretation of them, using Leonard-Barton's (1998) notion of cycles of adaptation.

4.3.1 Diagnostic Imaging Order Form

We first saw this electronic form (e-form) presented at a joint advisory committee meeting (JAC) in April of 2013. It was presented as a way to speed data entry for outpatients who would be visiting diagnostic radiology and nuclear medicine. It was a 5-6 question, yes / no form. Our first reaction (written in our field notes) was that there were some fairly nice elements to the e-form, in particular the ability to carry forward information from the patient's history (e.g., if they had a clip or other implant).

The provider reaction was less positive. The main question was why providers would need to enter the information at all, since (a) this used to be done by nurses or clerks, and (b) radiology would re-check the information when the patient came for their visit (since patients could be harmed by an error in the information). The track lead for this area explained that it related to the scheduling of imaging ap-

pointments, for example, needing to know creatinine levels for scheduling certain tests for patients with kidney dysfunction. The diagnostic imaging providers said "it will cripple them"[2] if this information is not captured each time when an appointment is requested. This was confirmed in an interview a few months later with a radiologist.

The discussion continued, with a degree of contention about who was right. One participant asked whether physicians who would be ordering tests had been consulted in the development (radiologists rarely place orders; they only receive them). Providers challenged why this had to be entered every time. One answer to the latter question is that the organization had chosen to implement CPOE but not CLINDOC. So the data for diabetic patients or those with hypertension would not be documented electronically and therefore couldn't be pulled into the order form from the chart.

Little was resolved in the discussion, although there was a plan to review it again and perhaps try to find some way to pull the data from somewhere to make it available so it didn't have to be entered each time. The discussion concluded with the meeting chair (a former nurse who was now acting as provider track lead) saying: "Let's kill this (i.e., move) before it kills us".

The issue came back again in the next meeting, a month later. It was clear that the providers hated the form (this is exactly what one of us wrote in her field notes) and felt that radiology was being "unreasonable". They had had a meeting and seemed to make some progress, but then radiology pushed back again saying they had to have the information to meet their professional standards (and protect their license). This was corroborated in our interview with a radiologist who argued that the issue was about doctors trying to avoid their proper accountability. According to the radiologist they are supposed to complete the requisition in full (and the information requested has not changed). But in the paper world, they might well have signed blank requisitions and then had them completed by a nurse or a clerk or a medical secretary. This violates college of physician guidelines but is a common workaround. The Clinical Transformation Project, specifically the component related to CPOE, would not allow this to continue.

The issues raised by the providers related to (a) whether the data being requested was relevant (i.e., do I have this information when I'm ordering the test?) and (b) the fact that inpatient DI orders were now being handled the same way as ambulatory orders – and this seems to be part of where the increased stringency is coming from.

The discussion/debate continued until the provider track lead intervened: "we are circling the point". At this point, the chair sought one person from radiology and one from physicians to make a decision for what will happen at the start. The physicians were then encouraged to "try it for a few months and see how it works" and then adapt the process further.

Our field notes record a pattern of radiologists trying to "sell" the providers on trying it out. The providers were questioning whether radiologists would ever be willing to change, and the team was saying they will, even though the recent meetings suggest that they won't at all! They were also trying to work on some technical solutions (can they flow through some information from the electronic chart without full CLINDOC) but they did not have that issue settled.

Eventually the project sponsor suggested that it can be taken to steering. The provider track lead suggested sending it to the executive sponsor and the Medical Advisory Council. These moves appeared to be intended as threats (appealing to a higher authority), and this sort of escalation (debate, debate, threaten…) was a recurring pattern across other instances.

When the issue came back 2 months later (July 2013) a bypass option had been added to the form, specifically to accommodate emergency/trauma situations where the information could not be ac-

[2] Quotes are taken from our field notes unless specifically noted.

quired. There was a discussion about auditing the bypass use to make sure providers were not abusing the system to avoid doing things they were supposed to.

4.3.2 Instantmessage

This issue relates to a way in which messages are shared within the EMR system. There is a message centre built into the system where workflow elements are directed (e.g., orders for approval when created by someone other than the provider, test results to be reviewed, etc.). But as an email-like system, it depends on the provider going into their inbox, finding a request, and acting on it.

A second tool, which we'll refer to as *instantmessage*, was explained at a meeting in September 2013. When it was raised in the meeting, several of the providers were opposed. They explained their concerns as related to a couple of issues. The way that the functionality worked is similar to popular IM tools. Communications would be sent around between various members of a care team in real time. Any actor in the group could add another party to the communication if they felt they needed to be involved. At any point in the discussion, any participant could save the message chain to the chart. This ability to save is an important feature as it allows a set of care-related messages to be preserved, but it was also the point of contention. The providers were concerned that they could be copied without their consent into a conversation, then have it saved and as a result have medical-legal liability for what was discussed in the conversation. With an open IM-type conversation, it was also possible for discussions to involve multiple patients (we need to do X for Mrs Jones and Y for Mr. Patel). And then this could get saved to one of the patients' charts thus violating the other's privacy.

The first time the issue was raised (September 2013) there was a great deal of confusion. The distinction between message centre (email) and the instantmessage functionality (IM) was not very clear, and the way that the EMR systems' messaging tools would relate to the hospital's email system (Groupwise) was also ambiguous. So the decision was made to go and get more information.

In November of 2013, the issue came back to the committee. The providers were adamant that it should not be turned on for the reasons stated. To this, they added explanations that the vendor's guidelines are that instantmessage should not be used for inpatient activities or for urgent activities, and that all users should be aware of the medical-legal implications of the ability of any participant to save the information to the chart. They also argued that there were other ways to get real-time communication such as calling or talking face to face, so their conclusion was that there was no reason for it, and therefore it should not be done.

Despite the vendor recommendations and the providers'' determined arguments, there was continued pressure to try it. As one of the project team members explained to the group, the providers in one of the hospital's ambulatory (out-patient) clinics used it and found it very helpful. The project team member, who worked closely with the ambulatory clinics in general also felt that it was worth considering because (s)he could envision some areas where it would be helpful. Moreover, experience in outpatient EMRs (e.g., family practice clinics etc.) had shown this type of functionality to be extremely useful. Two providers continued to strenuously oppose it as "the antithesis of the 80/20 rule". The discussion concluded with a unanimous recommendation from PAC/CAC to turn it off.

And yet, a month later the issue came back. The lead physician in the ambulatory clinic that used the functionality was clearly advocating for it. He viewed it as "the best functionality in the system". The team challenged the previously stated view that the vendor did not recommend it. The vendor does recommend it for outpatient but not inpatient settings.

This discussion led to another point of learning about the structure of the technical artifact, and another missing piece of the puzzle. Functionality like this is turned on or off at the role level. In the pre-CTP version of the system (which had been in place for more than 10 years) they had "a bazillion positions including like 47 different types of NURSE" (provider interview). Part of the development work was trying to reduce the number of unique positions because they added maintenance complexity to the system. For example, if you wanted to add a function for a nurse and there were 47 different

kinds of nurse, you had to add it 47 times. The organizations had decided to reduce physicians to a single position, whether ambulatory or inpatient, because there is some crossover (physicians who work in both ambulatory and inpatient care) which would require dual logins. So the choice was either on for everyone or off for everyone. One provider noted that individual physicians could turn it off, but viewed this as risky if you have incomplete conversations because a provider is not using it.

At the conclusion of the December meeting, the CTP team indicated that they would continue to investigate and bring it back again. Our field notes questioned the size and power of the group that was advocating for it because it was fairly clear that the committee members (or at least the most vocal ones) were very opposed yet the issue kept returning. In this meeting, two of the providers who'd been actively engaged in the discussions finally devolved into somewhat juvenile antics – joking, sarcasm and silly behavior. The issue, as recorded in our field notes, was that their rational arguments were being ignored over the arguments of largely one person who liked it.

Two months later, the next time our notes report it was discussed, the message was "it is off and will stay off until after go live. At some future point we will reassess".

4.3.3 Emergency Department Module

This issue was probably the most extreme rupture we saw. We'd heard lots of "issues" with the emergency department (ED) module throughout the development, beginning with a lot of concern from physicians that the system wouldn't support their needs. A lot of this was likely pushback against the concept of physicians having to directly place their own orders within the context of a busy ED (a 9 hour wait time at one of the hospitals). But throughout the discussions it came across as more of a case of "doctor resistance".

Then in August of 2013, a little over 2 months before the first go live when the second round of integration testing was taking place, a very large problem was uncovered. We first heard about it in a steering committee meeting (which was also the first time that many members of the committee were hearing about it).

What they had discovered was that the ED module in use had been heavily customized to meet the needs of the ED in the days when it didn't have to integrate with other modules in the EMR system. The customizations meant they were not using the vendor's standard coding, which compromised their ability to create new functionality that they now needed (e.g., a report on patients who left without being seen or who left with tests completed but not reported) as these create a medical legal obligation. The vendor's developers would tell them something could be done, but then their internal IT people would tell them it couldn't because "they weren't using that field that way".

We learned in an interview with physician, that this had come to a head in integration testing when they ported over the current application to the new EMR domain. "Basically they were trying to push existing data into the new database structure and it "blew up". It was garbage data" (physician interview).

At the steering committee meeting (Aug 18) the project sponsor reported the problem and the tentative hope that there was now a solution in place. As of the previous Friday they thought they had solved it but they were still testing. If the problem wasn't solved, however, there was a real risk of having to delay the first go live. So the project was moved to RED status (it had been in yellow since January). They discussed when to tell the physicians but decided to wait until they were sure what would happen to avoid creating impression the go live might be missed.

This issue was later referred to as "The ED Module Debacle" and the tiger team that got together was referred to as "ED Module Jail". This was a name given by someone on the build team because they were put into a special room with about 16 computers and various builders, users, testers all working on finding solutions. They were pulled off of any other duties and they had daily update calls to explain what was happening.

5 Discussion

The evolution of the project can be viewed from the perspective of the entanglements between material properties of technology and social interaction between participants in the project as they move through time. Our socio-material model of mutual adaptation (derived from Leonard Barton, 1988) is depicted in Figure 2. We attempt to depict what is actually a dynamic, rotating, 3 dimensional conception in a 2 dimensional space. Over time, as the technology and its material properties move from abstract conceptualizations, instantiated in the minds of individuals and in documents, slides, design tools etc. towards more concrete technology features that can be seen and experienced, there are con-

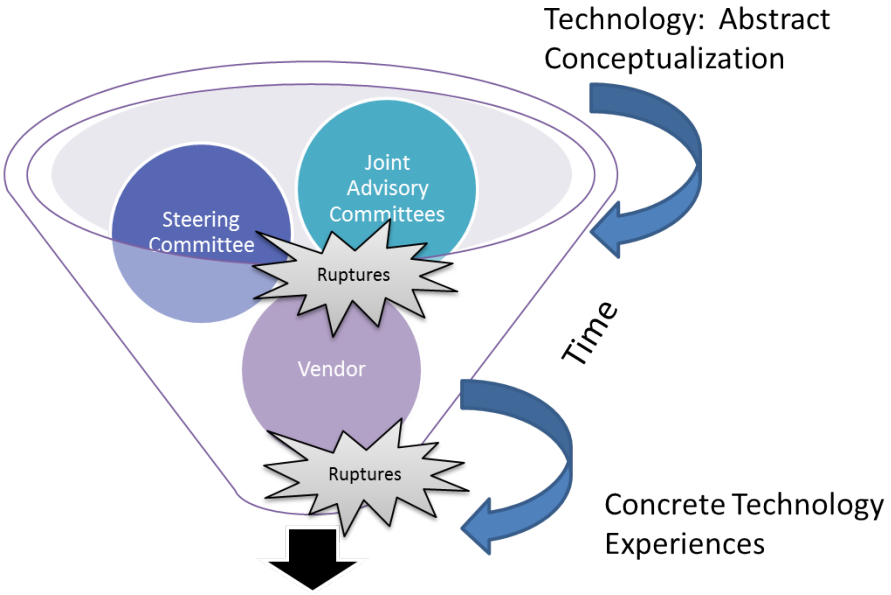

Figure 2: Emergence of Shared Knowledge and Understanding via Mutual Adaptation

current and mutually constitutive social activities occurring (imagine the funnel spinning – in motion). These occur between project participants (i.e. meetings, formal communications etc.) and can be viewed as opportunities to create a common understanding of what the technology is 'supposed to do' and how users will use it to do their jobs. As the technology is 'configured' and tested, and as stakeholders are trained the knowable features emerge and challenge socially constructed 'knowledge' of what the system will do. The actual capabilities come into relation with the 'ought to be' located in the minds of the stakeholders. Efforts to create shared understanding become visible as misalignments (in Leonard-Barton's model). We call these socio-cognitive-material events ruptures. A rupture is a phenomenon of realizing a degree of misalignment between users in relation to the developing technology or between what users want and what technology can do. We discuss our interpretation of the ruptures outlined above next.

The diagnostic orders e-form issue occurred early in the design phase when new workflow between groups was being analyzed and instantiated in the system. The conflict emerged between the ordering physicians and the DI group as each has interpreted the way things 'should' work in the new system differently. The DI group saw the system as an opportunity to reinforce "proper" procedures in the new system. But the ordering physicians saw the request as creating issues for their ability to complete the forms with relevant information. By defining the issue as "providers trying to not do their jobs" the radiology people were not open to hearing the specific issues that providers were raising. They ranged from trying to sell them on "try it out" to wanting to just force them. In our interview with the radiologist, (s)he said "it's fine if you don't want to complete the form…we just won't do the

test" because it is not safe. This redefinition of the problem around "safety" was another recurring theme. And yet, when asked what happens if the information is not provided (or is incorrect) the implication was not that the patient is exposed to risk but rather than a test might be delayed while the information was correctly verified. So the bigger problem seems to be efficiency, not safety.

Recall that the broad objective with the CTP project was clinical transformation. Within the context of our socio-material interpretation, the pre-CTP world allowed the 'mangle of practice (Pickering, 1995) to unfold in particular ways that shielded providing doctors with having to do all of the work required to order DI's since paper forms could be handed over to others for completion. As the new system was being designed, the new workflow (which requires online ordering by physician themselves) made old practices visible (to radiologists) and equally created new understanding of the additional work that ordering physicians would be required to undertake. Concurrently it empowered the radiology group to 'enforce' in the material properties of the system, practices they believed were safer and more efficient but which were much less efficient for the ordering doctors. It is therefore not surprising that the two groups would need to at some point, come to terms with the new inter-departmental social order as implemented in the new systems. Thus the rupture that emerged created the opportunity for understandings to be revealed, discussed and new understandings to be created and absorbed.

The *instantmessage* issue has many similarities to the DI e-form issue. It involves different stakeholder viewpoints (in this case a subset of the ambulatory clinic physicians – largely one team) and the other physicians at the joint advisory meetings. *Instantmessage* is a material property of the technology, entangled with workflow and the social interactions between clinicians during patient care. The one physician who was in opposition, while a member of the committee, was rarely in attendance so his viewpoint was almost always explained by others. This second-hand filtering of information was a real barrier to shared understanding because he never had to confront his peers' arguments. Resolution of the problem was also hindered by a lack of clear understanding of the technology and the interactions between various foundational technical decisions (in this case the number of positions) and the ability to resolve different stakeholders' views/needs/positions. In effect, the tasks of different physician roles (ambulatory vs. inpatient) demanded different communication flows instantiated within the technology but the technology was limited by being only capable of facilitating a single communication flow for the single 'role' of physician. The socio-material entanglement was at the level of the physician role at the expense of the workflow needs. Therefore, material inflexibility collided with socially constructed practices. In the activity of transforming clinical practice, this rupture exposed a lack of understanding with respect to the limitations of the system to support distinct physician needs by task. Since the team couldn't invoke safety concerns, resolution was harder to reach.

The ED module rupture came from the gap in understanding how existing customizations of the tool (pre-CTP) had changed the structure within the tool in ways that would not be consistent with the post-CTP version. Prior decisions about the socio-material entanglements of the workflow and system emerged as a major constraint to clinical transformation. Here there was not a gap between user groups with different needs, or between users and developers, but rather there was a gap between the in-house developers who had customized the system and the vendor developers who were trying to do things in the standard way. ED physician workflow was caught in the crossfire. The physician we interviewed expressed the view that "I just assumed that someone knew all of this, that someone would have had the information and known what to ask", but the vendor developers would have had no reason to know of the existing customizations (they perhaps should have known to ask) and the in-house developers were not being tasked with the new build because they did not have experience with CPOE – therefore they lacked the vendor's knowledge to foresee this problem.

In this case, the rupture did not evolve/unfold with the slowly increasing tension and entrenching of arguments followed by the appeal to patient safety. But like the others, it became clear in the interactions with the material artifact (at testing here vs. when confronted with the input form for the DI order

e-form). And it certainly produced a highly charged emotional reaction, followed by a realization of what was "unknown" and needed to be learned.

What we observed consistently across ruptures then was that understanding the event required understanding the 'mangle' (Pickering, 1995) of three things. First, the material properties of the technology need to be understood (as the technology design and development moves the tool from abstract to concrete). Second, the materiality of the workflow (as it is redesigned to take advantage of the new technology) plays a role in interpreting ruptures. Finally we saw at work the efforts by the observed teams to understand the first two issues in combination with the constitution/reconstitution of the social interactions and practices enacted by clinicians and physicians. We concluded that ruptures are not misalignments nor are they disagreements, rather they are socio-cognitive events which are wrestling with the socio-material nature of organizational life and they are necessary in the development or shared understanding between stakeholders. In Leonard Barton's model of mutual adaptation, misalignments between organization and technology are resolved through recursive adaptive cycles. A cycle of technology understanding implies revisiting the technology vendor, code, modules and the like. A cycle of organizational adaptation might include reformulating the project management process or changing workflow.

The ruptures in our model are also recursive cycles but they involve a more complex interplay between technology and organization (the mangle of practice) overlaid with recursive cycles of understanding concomitant with an emerging materiality in the technology artefact. Ruptures are characterized by tension, emotion, debate and a rupture may or may not be easily 'resolved'. Rather, as depicted in Figure 2, within the socio-cognitive-material model we have proposed from our data, ruptures can ebb away either towards resolution within the mangle (as shared understanding and knowledge) or rotate around back to tension, emotion and debate. It may take repeated cycles of efforts to achieve shared understanding before a rupture abates.

6 Conclusions

In this research, we developed a model of the evolution of shared understanding among multidisciplinary stakeholders engaged in a transformational IT-enabled organizational change effort. The presence of shared understanding between diverse stakeholders of a technology is a key driver of business-IT alignment and it is seen as underpinning successful adaptive, IS development activities. While prior research has considered the need for and value of shared understanding amongst stakeholders during the design, development and implementation of IT, we lack insight into how such shared understanding evolves and emerges during this timeframe. Our study proposes a model for understanding the evolution of shared understanding as a phenomenon that unfolds overtime, within the context of negotiating the constitutive entanglement of the social and the material.

Our principal contribution is in taking Leonard Barton's model of mutual adaptation (Leonard Barton, 1988) and adding a socio-materiality perspective (Leonardi & Barley, 2008). With this, we examine the phenomenon of systems design and development activities that produce shared understanding as a valuable alignment mechanism. We identify ruptures as detectable and important phenomena that contribute to the difficult work of evolving a shared understanding amongst diverse stakeholders. Even as they take stakeholders (including users and designers) backwards to original systems goals and visions, they also help the project/stakeholders make progress towards effective design and development decisions for the new technology. Ruptures thus emerge as a critical event in this unfolding phenomenon. These are naturally occurring events that are uncomfortable, unavoidable, perhaps political, but we would argue, essential to success.

7 References

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