Technology Trouble? Talk to Us
Findings from an Ethnographic Field Study

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ABSTRACT
The notion that the design of technology is only fully completed when in use [23] is shared by many who now investigate user participation in design and the domestication of new technologies. Taking this idea as our starting point, we developed a research to action project with a major Canadian hospital. Our goals were to address technology implementation issues that arose as most units in the hospital moved to a new building, in which most technology (ranging from wired beds to drug dispensing machines) was new. This paper reports our findings from this project. Emphasis is placed on how institutional arrangements influenced the range of socio-technical possibilities that could be pursued [7]. Work practice problems are discussed in relation to the meso or organizational contexts, including organizational, vendor and staff actor networks.

Participant interventionist, technology implementation, meso level analysis, organizational problem solving, ethnography, intervention, actor networks

1. INTRODUCTION
Karasti [11] has suggested that the role of *participant interventionist,* based on being a participant observer, necessitates carrying out fieldwork to construct an appreciative understanding of work practice before turning into a participant interventionist. The term participatory interventionist refers to ethnographic work undertaken in order to intervene with professional software designers, with the end goal of intervening in software design. We use the term *participant interventionist* here to refer to work undertaken in efforts to improve the implementation of technology in a Canadian hospital. Building on the notion that the design of technology is not fully completed until it is in use [23], we worked as participant interventionists with the aim of identifying and resolving work practice problems that occurred as several units of a large Canadian hospital moved into a new building, where most technology was new.

Work undertaken within the participatory design community has typically focused on interventions at the software development and design stage. However, as companies have increasingly purchased off the shelf solutions, some [20] have advocated for greater involvement of end users in system selection. Although end user involvement in system design is an ideal to be pursued, it is not always possible [20]. Our work illustrates that even when hardware and software purchasing decisions have been made, participant interventionists can make important contributions to work practice research through the application of ethnography with the intention of intervening in technology implementations.

We illustrate this point through discussion of the Technology Trouble? Talk to Us! Project we developed and delivered in a Canadian hospital during the move of several units to a new facility. In this paper we discuss issues that arose in relation to two technologies: automatic drug dispensing machines and keyboard trays. In presenting our findings about these two technologies, we illustrate the complexity of technological problem solving in a complex health organization, and particularly the significance of meso level support in the resolution of work practice issues that occur at the micro level. Our objectives are twofold: to illustrate the potential contribution participant interventionists can make at the implementation stage, and to underscore the importance of the meso or organizational level in resolving micro level work practice issues.

The work practice issues that we describe in this paper came to our attention through ethnographic field study of new technology use during and after 1,500 staff moved into a newly opened building (called the Tower) at Vancouver General Hospital. Although the initial intention of our research was to study the automatic drug dispensing system (ADS), the nurse call system and the ceiling lifts used for patient handling, during the course of our observations we realized that we had underestimated the problems that would arise with the implementation of less complex technologies, such as keyboard trays. Consequently, we revised the scope of our inquiry in order to address problems arising with these technologies, while continuing to investigate the ADS and other more complex technologies.

Our focus was on identifying work practice problems staff experienced in relation to technology. The underlying logic in this approach is that new technologies engender new work procedures and as a result alter existing workflows, both those directly related to the technology and those that are seemingly irrelevant to the technology. Shortly before the move we argued that we could improve technology implementation processes through identification of problems that would arise with the introduction of new technologies in a new work environment. Situated in the research environment as a member of a team responsible for professional and work practice issues and as an independently funded researcher, Balka argued that the provision of research

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support to front line staff and management about socio-technical challenges that arose during the move into the Tower would contribute to the identification and resolution of issues and would help with the changed workflows.

In meeting the objectives of our study, we played a key role in identifying numerous problems staff faced in their day-to-day activities. We raised those issues with management, who were responsible for finding resolutions to problems or deeming them unworthy of attention. We were able to identify issues that would have remained unnoticed had we not been present on site conducting observations. Finally, in listening to staff voice their concerns, we were able to alleviate some frustration that staff experienced as they negotiated use of numerous new technologies.

2. BACKGROUND

During late May and early June 2003, the first phase of the Tower Move project (which relocated most hospital units at Vancouver General Hospital into a new building called the Tower) was completed. Planning for the Tower began several years earlier; construction began in 1988. The first two floors of the tower were occupied in 1996, however monetary constraints put the remainder of the project on hold until 1999, after the hospital was able to secure sufficient private and public funding. In May of 2003, the tower was ready to house 459 patients.

During the building planning phase and much of the construction phase, the Facilities Planning and Construction department was responsible for the new tower. This allocation of responsibility was based on the seemingly natural fit between the jurisdiction of the Facilities Planning and Construction department and the activities expected of contractors working on the tower. However, during this time other departments initiated their own projects related to the tower. For example the Capital Acquisition department started purchasing equipment for the tower, while the Information Management team began specifying communication technology requirements. Six months prior to the scheduled move date it became clear that an organizational body was required to coordinate these highly interrelated activities, and that moving patients had to involve the operational units. Two directors were assigned to co-lead the Tower Move Project. It is worth noting that other facilities report spending up to two years in the planning phase of a move of this magnitude.

According to the Tower Move Project charter, the objective of the Tower Move project was to integrate the various independent departmental projects related to the move and "to ensure the timely, efficient, and successful move of identified clinical areas into the tower at the VGH site with minimal disruption in the care and workflow, while ensuring patient and staff safety" [27]. What set the move into the Tower apart from other moves within the facility was that the Tower was equipped with the latest technology, ranging from technology as complex as the automatic drug dispensing systems to less complex technology such as new chairs and computer keyboard trays. One of the assumptions of the Tower Move Project team was that all the required equipment and information systems would be purchased, installed and properly functional prior to move dates and that construction would be completed in advance of the scheduled move dates [27].

Reflecting varied experiences in technology design and implementation, our project (the Technology Trouble project) was based on tenants of socio-technical research. Socio-technical research takes as its starting point the notion that "plans differ from situated actions" and that the design of technology is not fully completed until it is in use [23]. Thus, the Technology Trouble research team had as one of its goals the documentation of situations where plans differed from situated actions in a manner that interrupted work practice. Articulation work and work-arounds often fill the gap between plans and situated actions [1]. As such we saw the identification of articulation work and work-arounds as an important source of information about work practice and work flow problems. The insights gained through our examination of such practices played an important role in bringing the problems staff faced to management's attention. Working with the directors responsible for the move (see Section 3), the Technology Trouble team identified problems experienced by staff, and took those issues to the directors responsible for resolution of those problems.

3. METHODOLOGY

Although participatory design projects have typically focused on end user involvement in technology design, as fewer companies have engaged in custom built software, increasingly advocates of participatory design have turned their attention to end user participation in system selection [20] and system implementation. The project described here was undertaken within such an action-research framework. Designed to bridge the gap between theory, research and practice [10], action research generates research about a social system while trying to change it [9]. Action research is particularly well suited to research aimed at problem solving and improvement [9]. In action research, researchers are experts in research methods, while practitioners are experts in the object of study [12] — in this case, work practices on their units.

The Technology Trouble project followed a model of action research termed the professionalizing approach. "The main aim is the improvement of professional practice at the level of organizational and cultural change, rather than in terms of a challenge to existing power relationships, or the involvement of users" [9, p.45]. The overall research question was not generated at a grass roots level with the input of research participants. In contrast, our research question originated as part of a pre-existing research project that had as its goal the investigation of work practice issues arising with new implementations of technology in the health sector. Once Technology Trouble team members were in the field observing and interviewing, issues identified by unit staff became the focal point of our work practice investigations.

The availability of research funds from the grant combined with Balka's role at the hospital as a member of the professional practice leadership team both had an impact on the design of the research project. These circumstances made it possible for the Technology Trouble team to approach the directors responsible for the move and volunteer to provide support to both the directors and staff concerning technology issues during the move, while at the same time meeting our own research needs.

Recognizing the limitations of having had only limited end user involvement in system selection processes, the Technology Trouble project focused on the moment of use as advocated by Suchman and Jordan [23]. Extensive observation and informal interviews conducted during and after the move focused on

documenting end user's difficulties during system implementation processes. The research team members acted as mediators between the social, and the implementation team, along the lines advocated by Westrup [29]. An ethnographic approach was undertaken as it often provides "a much better means of anticipating the dynamic effects on work organization" [18, p.21]. The Technology Trouble team focused on documenting end user's difficulties during system implementation, communicating problems to the directors responsible, facilitating resolution of problems identified, and communicating results (including the dismissal of some problems and the progress of other problems) to front line staff.

In anticipation that we might be asked questions about the new technologies we were studying, we participated in the same initial training about use of the nurse call system and the automatic drug dispensing system (ADS) that staff received. In addition, by roaming between different units during the move we were able to share the knowledge we had gained in one unit with staff in other units, thereby building on the existing knowledge base and helping staff to resolve problems. The extent to which we participated in solving problems on the spot depended upon the cultural norms of each unit and the personality of individual unit staff members. For example, at the Palliative care unit which is mostly made up of volunteers, the unit clerk eagerly solicited our support and participation in the set up of the nursing station during the move, while in the Neonatal Intensive Care Unit we assumed a more passive role.

3.1 Data Collection

Various data collection methods were employed. Observations and interviews were undertaken on all units that moved to the Tower, which formed the basis of our understanding of micro (work practice) issues, and often provided insight into meso (or organizational) issues. During the two-week move period, considering all the activities that were taking place (and the high stress level of staff who were struggling to acquaint themselves with the new wards, the location of supplies, and to learn how to use the many new and different technologies while continuing to provide patient care), we conducted passive observations on the units that had just moved in order to prevent additional disruption. Following the move, we continued our observations, and initiated more contact with staff (including informal interviews) while they carried on with their work. We were also able to solicit feedback from staff as part of the daily scheduled support rounds initiated by the Professional Practice Leadership Team at the hospital. By mid July, as staff settled into their new locations, our observations tapered off.

In addition to time that members of the research team spent engaged in staff rounds (typically 2 hours or more at a time), interviewing staff (e.g., unit clerks about keyboard trays) and conducting observations about specific technologies (such as the keyboard trays), members of the research team logged 45 hours of note-taking time in the field. During this time Technology Trouble Team members had contact with 411 people (which included multiple contacts with a single person).

In order to communicate our interest in hearing from staff about the difficulties they were experiencing in relation to technology, to make it easy for them to identify Technology Trouble team members, and to facilitate the collection of information from staff, the four researchers who collected data wore highly visible t-shirts with a "Technology Trouble? Talk to Us!" logo imprinted on both the front and the back of the shirt (see Figure 1). Although we also put other means of data collection in place (e.g., fax back sheets at nursing stations, a project e-mail address and phone number), our presence on the units with our visible t-shirts was the most effective means of data collection. These alternative means of communication were not the preferred method for reporting issues. During the research process, we received only three faxes from staff, and we received neither e-mail nor phone calls. Based on these figures, clearly face-to-face communication was the most fruitful method for micro level data collection.

Figure 1. Technology Trouble Logo

Our visibility encouraged staff facing problems to approach Technology Trouble team members for assistance. In consultation with the directors responsible for the move, it was decided that the researchers would share their skills and knowledge and provide staff with additional information about issues they were familiar with. When researchers lacked sufficient information and knowledge about a matter, they would encourage staff members to report the problem, and would supply information about the person and/or department who should receive a trouble report, if known. In addition, the researchers would record all problems observed in both their field notes and an Issue Log Spreadsheet (discussed later in this paper). Handwritten field notes were transcribed and subject to coding and analysis with the aid of Nvivo (qualitative data analysis software). Initial coding categories reflected the theoretical bodies of literature which informed the study (e.g., actor network theory, political economy), and were developed as part of a larger grant that explored several health technology implementations in different settings. Subsequent coding categories emerged through examination of the data collected through the Technology Trouble project.

Other data, particularly about the meso or organizational level were collected during meetings with various stakeholders, such as the Tower Move Project team (which included representatives from numerous departments, such as operations, maintenance, facilities, information technology and pharmacy) and during the Project Support Team meetings (which included the directors responsible for the move and coordinator for the Tower Move Project). During these meetings the Technology Trouble team brought an updated issues log spreadsheet for discussion. As resolutions to issues captured on the log sheet were identified the resolutions were noted in the issues log spreadsheet (see next section). We also gathered data from email communications with various people responsible for different aspects of the project. Meso level data collection was also conducted during our observations. We followed up on problems that had been raised and solution-oriented management interventions that took place.

3.2 Intervention Communication Strategy

Based on our initial proposal to the Tower Move Project directors, we planned to provide a weekly summary report to the Technology Trouble project sponsors (the directors responsible for the move, and representatives from IT, pharmacy and occupational health). We planned to share any new problems that surfaced during data collection, and our proposed solutions. However, during the first few days of the move we realized that no centralized and structured process had been developed for collecting feedback from staff and dealing with issues directly related to the move and the new environment. The existing support structures (such as the computer help desk) were available for the duration of the move, as were the regular procedures for requesting maintenance. During the two week duration of the move representatives from the various vendors were available on site during regular office hours and via pager during evenings, nights and weekends. A seven page document that listed contact numbers for reporting various types of problems was also distributed to staff. However, no centralized problem resolution structure was put in place specifically for the move, and it quickly became clear that staff both lacked the time to determine to whom to direct a trouble report, and that in many cases, the problems staff experienced were multi-jurisdictional, which resulted in confusion about which department should receive a trouble report. The pace of work deterred staff from clarifying such ambiguities.

To support our research and expedite the creation of our weekly summary reports we created a spreadsheet containing all the issues that we identified during data collection. The spreadsheet contained the following fields: Unique Identifier, Date Logged, Unit, Floor/Pod, Problem/Question/Issue, Possible resolution(s), Type of Problem, Type of Technology, Status, Source of Information, Person or group responsible, Due date, User name (if available), Date issue communicated to staff, Communication vehicle, Communication message, and Comments.

The database was then introduced to the Project Support team and after slight modifications they assumed ownership of the database. Researchers logged issues in the database that they were informed about or observed during their data collection, and would also email the database owner and inform her of the new issues. The issues were then discussed during weekly Project Support Team meetings, and assigned to the appropriate people. Issues were closed upon resolution or when after further discussion it was determined the issue was either a future consideration, out of the jurisdiction of the Tower Move Project team or a non-issue.

While our research team provided staff feedback to management via the issues database on a daily basis, the turn around time in resolving issues was not as fast as staff would have liked. Staff at various points indicated that that they felt the feedback they had provided had gone unheard and nothing had been done about the issues they had raised:

One of the key challenges that we faced in conducting a communication intervention was in upholding our ethical responsibility to staff to maintain their anonymity while at the same time insuring that their issues were addressed. Throughout the process we had to ensure that in reporting staff issues to management that we were not betraying staff trust in us. For example during the first days after the move we were told by a staff member that the manager of their unit had provided them with access to certain narcotics from the medicine carts. This workaround was employed by the unit manager in order to reduce staff frustration that occurred as staff waited in line to use the ADS to obtain narcotics for patients who were in pain. When the Technology Trouble team communicated this intervention strategy as a short term solution that could be employed by other units until staff felt more comfortable and at ease with the technology, the directors initially wanted to know which unit had developed this workaround so that it could be ended. We frequently commented that such strategies, though not best practice, allowed the staff to continue to deliver high quality care under stressful circumstances, and that such practices should be allowed until greater stability was achieved on the units.

During the 12 day period that 14 units moved into the Tower, Tower Move Project directors and other staff involved with the move met daily to address issues. In spite of these efforts, a more central and responsive issue resolution process was needed during the move to better address staff and patient requirements. Had there been a more structured issues resolution process in place during the move, as well as additional staff allocated to the resolution of move related issues, short term issues could have been addressed in a more timely manner, and the reoccurrence of similar issues on units that were scheduled to move at a later date might have been prevented. Failure to recognize that the design and implementation of technology is not fully complete until it is in use led the hospital to underestimate the occurrence of problems after the move.

3.3 Data Analysis

To organize the collected data and to help in creating links between data sources such as field notes, the issues log and background documents (such as memos circulated to staff during and after the move), qualitative data analysis software was used. All observations and interviews were typed and imported into NVivo. Other documents, such as meeting minutes, the project charter and the issues database were uploaded as proxy documents, where a brief description of the document was entered in NVivo and a link was provided to the location where the complete document could be located. Prior work that had been undertaken through the research grant (that was based on background literature and other field sites included in the study) had resulted in the creation of coding categories that were used to organize data. Additional coding categories specific to data collected through the Technology Trouble project were added. All documents were then coded based on these categories.

4. FINDINGS

While our initial plan was to study the ADS, the nurse call system and ceiling lifts, in this paper we will be presenting selected findings from our study concerning the ADS and a less complex technology-- under the desk keyboard trays. These two technologies have been chosen to illustrate that regardless of the complexity of a technology, organizational level practices impact usage at the micro level. Furthermore, these two technologies differ in the way they are positioned in the hospital. The ADS is considered a clinical technology (it contains medication for patients), and it has been championed by the Pharmacy department. In contrast, the keyboard trays are a non-clinical technology and although they were introduced to the hospital by

the Musculoskeletal Injury Prevention Team (MSIP), they were widely viewed as very much part of the infrastructure, and as such, they are not necessarily owned by a specific department, but rather were seen as the responsibility of each individual unit.

4.1 Automated Drug Dispensing System

4.1.1 Background

The automated drug dispensing system (ADS) is a tightly controlled system for dispensing medications. It is an automated cabinet made up of a touch screen monitor and keyboard on the top, and secure storage below which is accessible to nursing staff only after a password and required data (such as the patient's name, the desired drugs and dosages) have been entered (see Figure 2). On some units, a refrigerator is integrated with the ADS, and thus can only be opened by entering data into the ADS. In order to access the medication storage drawers and the refrigerator to remove medications, users who have been given authorization to access the ADS have to enter their user id and password. Once access to the ADS has been negotiated, the nurse must enter the name of the patient for whom she is removing medication, and then indicate via the screen which drug in which dose she wishes to remove. Once the required information has been entered, the drawers containing the specified medications unlock, a blinking light indicates the compartment where the drug is located and the staff member is able to remove the specified drug(s).

Figure 2. Automatic Drug Dispensing Machine (ADS)

The ADS replaced medicine carts used previously by staff for unit based medication storage. Automation of the drug dispensing system was undertaken to "allow nurses and pharmacists to spend more time on direct patient activities" [28; 19,4,21,14,30,17]. Seen as a means of improving drug inventory control and decreasing medication errors [28], the ADS system is connected to the hospital's central pharmacy database. It allows pharmacy to have up-to-date information about the inventory of drugs on each unit, required for restocking hospital units, and replenishing supply of the hospital pharmacy's drugs [28]. Password access makes it possible to monitor staff interaction with the ADS.

4.1.2 Work Practice and the ADS

With the implementation of the ADS, significant changes were made to work processes of both front line staff (mostly nurses) and the work processes of the pharmacy department. Through our observations it became evident that significant changes to work practice occurred for both groups with the introduction of the ADS, and it became evident that there were problems with the way the work processes had been redesigned when the ADS was introduced. This is not to say that work design can be fully completed prior to the implementation of new technology. We acknowledge that "rather than a linear design process that sees system development and implementation as separate, discrete steps, participatory design views system development as a continuous or rolling process, where design is only fully completed in use" [23]. Hence, it is often in use that the flaw of redesigned work processes surfaces, and at that point it is important to incorporate feedback from users into the design and implementation process and modify the technology or work processes accordingly.

One of the problems that surfaced with the ADS system revolved around the intravenous (IV) medication that required refrigeration. It came to our attention that although Pharmacy was responsible for stocking the ADS units, they were not placing the IV medication in the refrigerators controlled by the ADS. Pharmacy staff responsible for restocking the units (who with the introduction of the ADS went from stocking units with medications twice daily to stocking medications on an 'as needed' and often continuous basis) explained that they wanted nurses to be aware that the IV medication they had requested had been delivered. However, nurses were busy moving between patient rooms and the nursing stations, and were not necessarily aware of the delivery until they actually needed to access the ADS and had to enter the ADS room (generally located behind the main nursing station). Consequently, bags of IV medications often sat on top of the cabinet (rather than in the refrigerator) for quite some time before a staff member noticed them. We were also informed that considering the time it took to place the IV medication inside the refrigerator (access to the refrigerator is controlled by the ADS), that pharmacy did not have enough staff to assume this responsibility. The head of pharmacy further confirmed this explanation. However, since restocking was not part of the work routine that unit staff had been responsible for, they too saw this task as outside of their domain of responsibilities.

Nurses and pharmacy staff responsible for restocking unit supplies of drugs both resisted the task of placing the IV bags in the refrigerator after the introduction of the ADS. The time required to access the ADS for restocking and removal of drugs was underestimated, leaving both groups feeling pressed for time. Tensions about the extra time required to access the ADS played themselves out around placement of the IV bags in the refrigerator. This task was not incorporated in the work design of either work group and as a result the responsibility is being shifted between the two groups and has become a source of frustration. Initially, when the issue was raised with pharmacy, they took the necessary steps to accommodate front line workers as they settled into their new environment. Shortly after the move the responsibility was once again shifted to the front line staff.

The ADS technology also brought to light a nursing work practice (of splitting a dose of medication when the required dose was not available) that was frowned upon by management. The inventory control processes built into the ADS force staff to practice medication wasting (when a half of a pill or partial vile of a drug are administered, the unused portion is to be discarded rather than saved for later use). Although wasting is considered best practice (because unused drugs are returned to the locked ADS cabinet,

and can be neither mis-administered to patients nor removed from the unit by staff), the absence of a control mechanism in the past meant that prior to introduction of the ADS this practice was not enforced. Practices that pre-dated the ADS (which involved medication carts and locked drawers only for narcotics) allowed staff to pocket medication for later administration (a practice many saw as both more convenient (it saved nurses trips to the medication cart) and less wasteful (partial does of medication could be used, rather than thrown out).

The medication carts that were used prior to the introduction of the ADS functioned effectively as a boundary object. They supported the codes, habits and norms of both the nursing staff who administered medications, and pharmacy staff responsible for stocking the units' medications. In contrast, the ADS (which interfered with situated routines that enabled staff to smoothly perform their jobs) became disputed terrain in several boundary disputes (e.g., between nurses and pharmacy staff responsible for stocking units, between nurses and management, who wanted to 'clean up' practices deemed unsafe). [16] reported that "the conflicts, distrust, and constant need to 'go around the system' made it all but impossible for nurses to accept Meditrol (an ADS) as a boundary object reliable enough to supply them with the drugs and drug information they required from pharmacy."

As Suchman [24, p.54] pointed out, "when situated action becomes in some way problematic, rules and procedures are explicated for purposes of deliberation and the action, which is otherwise neither rule-based nor procedural, is then made accountable to them." The source of tension is between the 'proper practices' (or as Berg [3] refers to them, the protocols, which are guidelines based on structured work practices), and situated actions, which reflect the realities of facing contingencies and sudden events. For example, many units 'stockpiled' drugs so that when the pharmacy was closed at night, required drugs were available. Use of the ADS, which tightly controlled inventory, made this practice impossible, and left unit staff concerned about the availability of medications during night shifts.

The introduction of the ADS brought situated practices to light which nursing staff had developed to insure what Karasti [11] referred to as "smooth performance" in their jobs. While old practices may have been poor, they accommodated fluid nursing work. As Star and Strauss [22] maintain, these practices formed the articulation work that was practiced by staff to deal with unanticipated contingencies. This type of work is invisible from the linear work design models that were used as the basis of system design in the Tower, and the extent to which such practices were necessary to the smooth performance of nursing care (e.g., insuring the availability of an adequate supply of medications at times the pharmacy was closed) only became evident when they were no longer practiced.

4.1.3 ADS Discrepancy Reports and Work Process

During a visit to the Tower six months after the move, we observed a large bag overflowing with receipts on top of one of the ADS machines. Drug inventories are controlled through the ADS in part through a count back procedure, where staff count back, or verify that the locked storage drawer compartments that house the drugs contain the quantity of drugs indicated on the ADS screen. In instances where the quantity of medication in a drawer varies from the quantity listed, staff must type in an explanation, and locate a fellow staff member to witness the discrepancy. Once this procedure is completed, the ADS issues receipts in duplicate. One copy is kept by the staff member who reported or witnessed the discrepancy, and the other is retained for pharmacy. The bag of receipts on top of the ADS were discrepancy reports waiting to be picked up by the pharmacy department, which lacked both the staff to process the discrepancy reports and a procedure for processing the information gained from the discrepancy reports. Through further investigation we learned that pharmacy was aware of the bag of receipts, and that all discrepancy reports were supposed to be cleared from the ADS by the end of each shift. However, staff frequently did not clear discrepancy reports at the end of the shift which meant that discrepancy reports carried over to the next shift, and each staff member who subsequently required a drug that had a pending discrepancy had to go through the lengthy procedure of generating a receipt that indicated that a discrepancy existed.

The introduction of the ADS generated a new level of reporting (previously, only narcotic discrepancies were reported, however,; with the ADS, all discrepancies were reported) aimed at inventory and cost control, as well as reduction of medication errors. The failure to situate the ADS technology within its social context (in which nurses lack time, pharmacy was not adequately staffed during the transition to the ADS, and new monitoring procedures were introduced that added demands to both nursing and pharmacy roles) resulted in a situation where the potential of the ADS was, at best, only partially realized. Results from research about the impact of ADS have been mixed—some studies show a reduction in medication errors, while other studies have drawn attention to mechanical and human problems in their use [16,17,26]. Work reported here continues these debates.

4.2 Keyboard Trays

In an effort to reduce the incidence of repetitive strain injuries among staff who were required to frequently use computers, new under the desk keyboard trays were ordered for the entire building. As units moved into their new spaces in the Tower, we began hearing complaints about the keyboard trays. We first heard about the keyboard trays from a unit clerk, who was one of the few people who submitted a complaint using the 'Tech-Talk' fax sheets. The complaint read:

> Love the concept! However, the platforms can't be swung away/rotated/retracted enough to allow proper knee room under the counters. Specifically at the unit clerk's position, lots of knee bumping going on. Can't get close enough to the desk to write comfortably. The platform's range of motion is limited by the support brackets for the counter tops.

As with all of the other issues we heard about or identified (whether directly from staff, or indirectly through our observations), this issue was logged in our database and presented to the Tower Move Project team. Our first attempts to bring this issue forward failed. The issue was deemed a closed issue requiring no further follow-up. The decision to close the issue was based on the fact that the MSIP team had been involved in the decision to purchase the trays, and that the MSIP team had taken ergonomic standards into account in their selection criteria. It was thought that staff just had to learn how to use the new technology,

and once they did, there would be no problems.

A few weeks after the keyboard issue was closed we realized during observations that frequently people struggling with the keyboard trays. We began conducting more focused observations of people using the trays. We observed nurses squatting to use the keyboard just so they would not have to deal with trying to tilt or slide the tray. There were doctors stretching and bending to use the trays, and we observed various bodies taking various painful looking postures to accommodate the trays. Again we raised the issue during one of the meetings with the Tower Move Project team, this time when a member of the MSIP team was present. Once the problem came to the attention of the MSIP team, they took all the necessary steps to resolve the problem.

Figure 3. Staff Attempting to Move Keyboard Tray

It had initially been assumed that staff did not know how to use the trays, and thus were unable to slide or tilt them. A session was set up where staff from MSIP were to train a member of the Technology Trouble Team in the proper use of the keyboard trays, so that the Technology Trouble researcher (who maintained a constant presence on the units) could assist staff in learning how to properly use the keyboard trays. During this session it became apparent that the problem was the tray and not individual staff members. The vendor was contacted and after a few rounds of fixing individually identified trays all 80 installed units were deemed defective and replaced—an outcome that would have been unlikely had we not been present to observe difficulties and insure that they remained on the table as "open" issues during problem resolution processes.

As researchers, we were curious to know why the issue had only been reported once, although we had observed several occasions of difficult use. We approached the unit clerks at each nursing station to obtain their views on the matter. Through this process we realized that a few people had actually reported the problem, but that the Facilities and Planning department was dealing with an overwhelming backlog of issues and that after three weeks they had not yet been able to send anyone to look into the problem. A few respondents had just assumed someone else would take care of reporting the issue. Other users thought they were the problem and they were too embarrassed to admit not knowing how to operate a keyboard tray. In many units, staff had developed work-arounds, such as placing the keyboards on the counter tops and shifting the trays as far back under the desk as possible in order to prevent their knees from banging into the keyboard trays.

We later learned that these particular trays were chosen based on the positive feedback about similar trays previously installed in the radiology unit. In spite of good intentions, a frequently heard comment was 'why didn't we just get those simple sliding trays? The ones that IKEA has, the ones that are probably $40.00 each?' The decision to buy what turned out to be an entire batch of defective keyboard trays was undertaken in the interest of staff safety, and based on a prior success model. But as one unit clerk pointed out: "they keep saying that the keyboard trays are ergonomic, but the question is whose ergonomics? Were the trays designed for this narrow space?"

We began searching for additional information about the keyboard trays. In the process it was suggested that the trays that had been ordered and those that had been received were not exactly the same model. We attempted to locate the paperwork to verify this, but were unable to do so. In order for technologies to be functional, socio-technical approaches to system design and implementation advocate for users to be positioned at center stage [2]. In this case, although the intention was to support the user (by investing in ergonomically sound keyboard trays), good intentions did not—at least in the short term—produce a good result. The technologies were not designed for the narrow space behind the nursing station. The role of workers, their tasks, the tools they work with and the architecture of their work environments are tightly interwoven [2] and any system design should consider the interaction of all components within such networks.

The distributed nature of decision making about technology purchases (e.g., Facilities Planning and Construction undertook much of the responsibility for the physical site until shortly before the move, Capital Acquisition purchased equipment on the basis of decisions often made by staff (such as the MSIP team) within departments, and maintenance was responsible for addressing any problems with equipment such as the keyboard trays after the move in) made it difficult to address issues that involved the interaction of workers, tasks, tools and work environment architecture. In actor network terms, the actors were sufficiently aligned to acquire the technology, but a lack of alignment at the meso level inhibited the establishment of smooth work practices, and constrained users from realizing greater benefit from the technology. Alignment of actors during one phase of the technology design or acquisition process does not ensure that actors will be aligned in useful and productive ways during subsequent phases, such as implementation. As a technology moves from the design or acquisition phases into the use phase, different actors may need to be present or existing actors may need to fill new roles in order to insure smooth work practices. If technology design is only fully completed in use, emphasis should be placed on understanding the role of organizational actors in resolving work practice issues at the point of use.

5. DISCUSSION

Our experiences as participant interventionists in relation to the ADS and keyboard trays demonstrate the potential value that ethnographers can play at the point of system implementation. They also provide a focal point for discussions about the inter-relatedness of the micro and meso environments.

5.1 The Role of Participant Interventionist

These two cases illustrate that potential exists for ethnographically informed participatory intervention during implementation. Ethnography serves as a set of tools through

which articulation work and work-arounds can be identified. However, the collection of such information through participant observation does not necessarily lead to change. We were able to assume the role of advocate/ interventionists because we were able to complement our ethnographic insights with intervention strategies which were integrated enough into organizational frameworks for action to effect change. We believe that our ability to assume this role reflected the autonomy of our funding (the hospital did not control it), the autonomy of research team staff (although the hospital was paying part of Balka's salary, she holds a permanent job elsewhere, and other members of the team were all university students, employed by Balka), and the temporary nature of the project (which diminished the threat we posed to permanent staff).

The case with the keyboard trays illustrates that representing user perspectives to those responsible for implementation can produce positive results. The ADT case suggests that ethnographic intervention earlier in the process may have smoothed implementation. As participant interventionists, we were able to bring matters to the attention of organizational actors. With the keyboard trays, we were able to effect enduring change. With the ADS, IV bags and refrigerators, we were able to effect a change for a short time. The problem with the keyboard trays continued until mid October, when we were notified through e-mail that the final problems were being resolved with the keyboard trays. Had we not been present on site conducting observations, the problematic keyboard trays would most likely have been addressed as isolated incidences, rather than dealt with as a problem requiring intervention at an organizational level. Our participatory intervention uncovered eighty defective keyboard trays (the entire number installed) that had cost $36,400.00 (excluding installation, removal and reinstallation). Our intervention was successful in improving work practices.

Although we were able to facilitate communication between nursing staff, pharmacy and management about issues that arose in relation to the introduction of the ADS, problems remain unresolved. There are several possible explanations for this (e.g., we were less successful effecting change in relation to the ADS because the professional groups involved held more power than those groups involved with the keyboard trays; that resolution of ADS issues required additional staff, which we could not deliver). It should also be noted however that the management and communication strategies put in for the move, (including our communication interventions) had ended by September. There ceased to be a formal communications arena through which enduring issues could be brought forward and resolved. By the time these forums for communication had disappeared resolution of the keyboard trays was nearing completion. However, issues related to the ADS (such as the overflowing bag of discrepancy reports) were still surfacing. Our experiences thus also underscore the importance of building problem resolution processes that crosses functional units within an organization, and that remain in place through successive phases of a project.

5.2 The Interaction of Micro and Meso Environments

5.2.1 Inter-Arena Communication

Gartner and Wagner [6] distinguish between three arenas in which participation in system design occurs: in designing work and systems (here referred to as the micro level); in designing organizational frameworks for action (here referred to as the meso level); and in the industrial relations context (which constitutes part of what we refer to as the macro-level). The mechanisms through which these arenas are connected has been a matter of debate. Building on Giddens' contribution of structuration theory (attempts to address the interplay between social structures and human action [15]), [25] foreground the role of communication in their efforts to link micro and macro processes related to the computerization of work. They argue that organizational networks are concerned with the mobilization of authority and resources, and that each level-- local and global-- depends upon the other. In contrast to Giddens, they assume communication to be "how power is exercised, legitimated, and understood in communities of people engaged in a collaborative enterprise" [25].

Groups have ties to larger organizational contexts (or arenas) that are mediated by circumstances (such as the transfer of IV bags to clinical units). The interlinking of groups in an organization results in "the construction of units of co-orientation and collective action involving, not just individuals, but groups, and the organization itself" [25, p.97]. In actor network terms, realignments of actors within a network often occur in relation to non-human artefacts (such as conflicts over keyboard trays). Such artefacts may assume the role of actors in boundary crossing between arenas in which system / work design is situated [6]. Resolution of issues that are evident at the micro level which involve multiple groups (such as the conflict over IV bags) typically require organizational networks that are concerned with the mobilization of authoritative resources—in our case, the involvement of directors of several departments, including pharmacy and unit managers.

People in an organization who participate in inter-group communication (in Gartner and Wagner's [6] terms, inter-arena communication) have a different status from others. They represent groups in one manner or another, and, as such, are institutional actors who assume roles in stable patterns of intermediation [6]. Strategies for managing or resolving conflicts often involve boundary crossings between different arenas-- the work and systems arenas, the organizational framework for action, and the industrial relations arena. In the case of the ADS, a combination of factors (including power dynamics between professional groups, and the disappearance of mechanisms that supported inter-arena communication with the conclusion of both the Tower Move Project and the Technology Trouble Project) constrained boundary crossing between the different arenas. Consequently, problems (e.g., with discrepancy reports) remain.

The Tower Move Project brought institutional actors together in new ways that supported inter-arena communication, and the disappearance of communicative forums created through the Tower Move Project at the conclusion of the move hindered resolution of inter-arena conflicts. Inter-arena communication often serves as a link between actors who are in conflict with one another at the micro level, and the mobilization of authoritative resources at the meso or organizational level that is required for resolution of conflicts between groups at the micro level. Had the project charter extended beyond the move and immediate post-move period, the accountability relationships set up for the duration of the move would have persisted. With the dissolution of the Tower Move Project, responsibility for post

implementation change management was unclear. The cases described here underscore the importance of the meso or organizational level in technology implementation.

5.2.2 Exercising Organizational Power

At the meso level, the focus is on organizational motivations and structure. According to actor network theory, the organization that as a network operates smoothly, and "acts as a single block" [13, p.4], disappears and is replaced by the action and the actor of that action. The individual components making up the organization become visible when the organization fails to produce the intended outcomes, and when an end result is not achieved. "Good usable systems disappear almost by definition. The easier they are to use, the harder they are to see" [5, p.33]. The actor-network approach is concerned with the way in which organizations "hold together the bits and pieces out of which they are composed; how they are sometimes able to prevent those bits and pieces from following their own inclinations and making off; and how they manage, as a result, to conceal for a time the process of translations itself and so turn a network from a heterogeneous set of bits and pieces each with its own inclinations, into something that passes as a punctualised actor" [13, p.5]. For example, pharmacy as a network often appears to act as a single block. While nurses are removing their patients' medications from the ADS drawers the work practice components that make up the pharmacy network are invisible to them. It is when they run into a problem and have difficulty locating a medication they need that the problematic work processes are magnified and the fragments of the seemingly integrated network come into focus. A well-managed pharmacy network will mask the heterogeneous networks that create it, and end users will view it as a single unit.

Law [13] argues that the process of punctualization, (viewing the network as one unit rather than viewing the complexity of the individual components forming the network) is attained through the exercise of power. As a process it involves achieving equilibrium between the forces of resistance to hierarchical ordering of power, and the hierarchical exercise of power. For instance, in the case of malfunctioning keyboard trays, a user resisted the network and raised her problems related to the trays. When the issue was raised during a meeting with managers, it was closed on the basis that ergonomic standards were taken into account in ordering the trays, and thus, fault must be with the users. The trays were seen by management as part of the infrastructure (that should have been invisible to users). For users, the trays were visible precisely because they failed to work. Under such circumstances where staff brought a complaint forward that is left unaddressed, staff often make do (recognizing the futility of resistance), which provides an appearance of equilibrium, but in reality the silence and inaction is a concealed form of resistance.

The exercise of power is relative. The organization as a whole has a hierarchical system, in which the exercise of power is manifested. Specialization and the division of labour, however, result in the creation of functional divisions within the organization that in many cases act as independent units and develop their own hierarchies of power. It is the conflict between these different hierarchies of power and the jurisdictional boundaries of each that causes additional problems. For example, during our observations it came to our attention that the wiring of one of the ADS units was preventing the closure of a narcotic drawer. The issue was raised with staff and while they were aware of the problem, it was not clear to them which department they should have contacted to have the issue resolved. Staff wondered if the wiring of the ADS was an issue that would be dealt with by Pharmacy, (who "owned" the machine). But the ADS machines were computerized, which might make the IT department responsible for them. As the problem existed because a cable was not fixed in place, responsibility for resolving the situation might rest with maintenance.

The challenges that occur at the link between the micro and the meso level can be understood in relation to the fact that the technologies which in some sense were most problematic, were infrastructure technologies. These technologies failed to achieve the status of infrastructure in part because of jurisdictional issues related to the taken for granted nature of the technologies. Bowker and Star [5] suggest that infrastructure is a collective term that refers to the subordinate part of an undertaking-- that infrastructure refers to substructure, or foundations, as well as to what a person does or did -- it is an act that proceeds business. Hanseth [8, p.6] identifies two of the significant features of infrastructures: they have a supporting or enabling function and are large and complex, and they are shared by a larger community. Infrastructure is relational. Something "becomes infrastructure in relation to organized practices" [5, p.113], and "infrastructure occurs when the tension between the local and the global is resolved" [5, p.114], and when local practices (e.g., insuring an adequate stock of medications at night) are accommodated by a larger scale technology (new pharmacy unit stocking schedules, introduced in relation to the ADS), which can be used in a natural, ready-at-hand fashion. Acknowledgement of problems with keyboard trays may have been hampered because they were viewed as infrastructure—a taken for granted technology. One element of taken for granted technologies is that their use requires little explanation or expertise.

6. CONCLUSION

Many of the issues addressed here stress the importance of the meso or organizational level in preventing and solving problems, particularly those related to infrastructure. For example, the keyboard tray case suggests that processes surrounding the purchase and implementation of technologies should be re-designed—a process which is now being addressed through a subsequent grant concerned with technology governance in health settings. Resolution of micro level problems requires good communication at the meso or organizational level, especially in instances where several jurisdictions or arenas may be involved.

A new approach to project management and execution that makes inter-arena communication a priority may hasten the resolution of micro-level problems. An organization's communication workflow should be reviewed prior to the implementation of new technologies, to insure that communication workflows are structured in a manner that will support the resolution of multi-jurisdictional technology problems.

To achieve successful intervention strategies at the micro level, it is important that intervention teams act on what they hear and see, rather than what they assume. Creative approaches should be utilized for informing staff about issues raised and how they are

being addressed. This requires more direct communication with staff before, during and after technological change.

This research has shown how qualitative research methods can be an extremely effective means of identifying and resolving organizational and technological problems, and evaluating socio-technical systems. Furthermore, it has shown that rapid response evaluation can play an important role in problem identification and resolution, and lead to economic savings. Developing multi-jurisdictional means of problem solving is an important aspect of resolution of multi-jurisdictional problems. Viewing socio-technical problems through a lens that links micro level problems with meso level activities can improve organizational outcomes. Hence, emphasis should be placed on meso level support for micro level interventions, which might be complemented by longer-range project commitments.

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8. REFERENCES

[1] Balka, E. Sometimes Texts Speak Louder than Users: Locating Invisible Work Through Textual Analysis. In A.F. Grundy, D. Kohler, V. Oechtering and U. Petersen (Eds.). *Women, Work and Computerization: Spinning a Web from Past to Future.* New York, Springer-Verlag, 1997, 163-176.

[2] Berg, M. Patient care information systems and health care work: A sociotechnical approach. *International Journal of Medical Informatics, 55* (1999), 87-101.

[3] Berg, M. Working with protocols: A sociological view. *The Netherlands Journal of Medicine, 49* (1996), 119-125.

[4] Borel, J.M., and Rascati, K.L. Effect of an Automated Nursing Unit-Based Drug Dispensing Device on Medication Errors. A*merican Journal of Health-System Pharmacy, 52* (1995), 1875–1879.

[5] Bowker, G., and Star, S.L. *Sorting things out; Classification and its consequences*. Cambridge, Mass: MIT Press, 1999.

[6] Gartner, J., and Wagner I. Mapping actors and agendas: Political frameworks of systems design and participation. *Human-Computer Interaction, 11* (1996), 187-214.

[7] Hanseth, O., Monteiro, E., and Hatling, M. Developing information infrastructure: The tension between standardization and flexibility. *Science, Technology and Human Values, 21,* 4(1996), 407-426.

[8] Hanseth, O. Information technology as infrastructure. *Gothenburg Studies in Informatics Report #10 (Doctoral Dissertation).* Department of Informatics, Göteborg, Sweden, 1996.

[9] Hart, E. and Bond, M. *Action research for health and social care: A guide to practice*. Buckingham: Open University Press, 1995.

[10] Holter, I.M., and Schwartz-Barcott, D. Action research: What is it? How has it been used and how can it be used in nursing? *Journal of Advanced Nursing, 128,* (1993), 298-304.

[11] Karasti, H. Increasing sensitivity towards everyday work practice in system design (*Academic Dissertation*). Department of Information Processing Science, University of Oulu, Finland, 2001.

[12] Korpela, M., Mursu, A., Abimbola Soriyan, H., and Eerola, A. Information systems research and information systems practice in a network of activities. In Dittrich, Y., Floyd, C., and Klischewski, R. (Eds.) *Social thinking – software practice*. Cambridge, Mass: The MIT Press, 2002, 287-308.

[13] Law, J. *Notes on the theory of the actor network: Ordering, strategy and Heterogeneity*. Centre for Science Studies Lancaster University, 1992.

[14] Lee, L.W., et al. (1992). Use of an Automated Medication Storage and Distribution System. *American Journal of Hospital Pharmacy, 49*, 851–55.

[15] Monterio E., Hanseth O. Social Shaping of Information Infrastructure: On Being Specific about the Technology. In: Orlikowski W., Walsham W.J., Jones M.R., DeGross J.I., Eds. *Information Technology and Changes in Organisational Work.* New York: Chapman & Hall, 1995, 325-43.

[16] Novek, J. IT, gender and professional practice: Or, why an automated drug distribution system was sent back to the manufacturer. *Science, Technology, & Human Values, 27,* 3 (2002), 379-403.

[17] Novek, J., Bettess, S., Burke, K. & Johnston, P. Nurses' perceptions of the reliability of an automated medication dispensing system. *Journal of Nursing Care Quality, 14,* 2(2000), 1 – 13.

[18] Randall, D., Hughes, J., and Shapiro, D. *Systems development – The fourth dimension perspectives on the social organization of work*. Paper presented at he SPRU CICT Conference, Sussex University, 1991.

[19] Ray, M.D., Aldrich, L.T., and Lew, P.J. Experience with an Automated Point of Use Unit-Dose Drug Distribution System. *Hospital Pharmacy, 30,* 1(1995), pp. 18, 20–23, 27–30.

[20] Robertson, T. Participatory design and participative practices in small companies. In Bloomberg, J., Kensing, F., and Dykstra-Erickson, E. (Eds.) *PDC '96: Proceedings of the Participatory Design Conference*. Cambridge, Mass: Computer Professionals for Social Responsibility, 1996, 35-43.

[21] Schwarz, H.O., and Bradowy, B.A. Implementation and Evaluation of Automated Dispensing Systems. *American Journal of Health-System Pharmacy, 52*, (1995), 823–828.

[22] Star, S.L. & Strauss, A. Layers of silence, arenas of voice: The ecology of visible and invisible work. *Computer Supported Cooperative Work*, *8*, (1999), 9-30.

[23] Suchman, L., and Jordan, B. Computerization and women's knowledge. In *Women, work and computerization: IFIP conference proceedings*, Amsterdam, 1988.

[24] Suchman, L. *Plans and situated actions: The problem of human-machine communication*. Cambridge, U.K.: Cambridge University Press, 1987.

[25] Taylor JR, Groleau C, Heaton L, Van Every E. *The Computerization of Work: A Communcication Perspective.* Thousand Oaks, CA.: Sage, 2001.

[26] Tribble, D.A. How Automated Systems Can (and Do) Fail. *American Journal of Health-System Pharmacy, 53*, (1996), 2622–2627. Vancouver Coastal Health Authority. *Tower Move Project – Project Charter,* 2003.

[27] Vancouver General Hospital chooses Omnicell for automated pharmacy dispensing http://www.omnicell.com/News/pf_release_display.asp?page=139 Accessed Feb. 12, 2004.

[28] Westrup, C. On retrieving skilled practices: The contribution of ethnography to software development. In Dittrich, Y., Floyd, C., and Klischewski, R. (Eds.) *Social thinking – software practice*. Cambridge, Mass: The MIT Press, 2002, 91-110.

[29] Wise, L.C., et al. Cost Benefit Analysis of an Automated Medication System. *Nursing Economics, 14,* 4(1996), 224–23