Giving Voice to Print Production Facility Workers: Representing actual work practices in the streamlining of a labor intensive production print job

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This paper presents findings from an ethnographic study of digital production printing, with a focus on a complex, labor-intensive production print job. The goal of the study was to inform the development of tools, processes and technologies to improve the efficiency of this kind of job within the print production facility. By documenting how work was done from the perspective of the people who did the work, our study ensured that the voices and perspectives of the workers were formally represented in the process of improving and streamlining the tools and print production facility workflows.

INTRODUCTION AND BACKGROUND FOR THE STUDY

This paper presents findings from an ethnographic study of a complex, labor-intensive print job in a digital print production facility. Management hoped to use the study to inform the development of tools, processes and technologies to improve the efficiency of this kind of job within their facility. A major goal of our study was to understand how the print job was done from the perspectives of the print production workers, so that any new tools or workflow designs would support the actual work necessary to complete the job. By documenting how work was done from the perspective of the people who did the work, our study ensured that the voices and perspectives of the workers were formally represented in the process of improving and streamlining the tools and print facility's workflows.

Our study focused on a quarterly high volume print job, described by the print production facility as complicated and labor-intensive. The job arrived at the printshop on a series of data tapes. The printshop organized the data into meaningful sequences of documents, printed the job, and organized the printed pieces into bundles that were ready for mailing. The final job included more than 400,000 sheets of paper, which were grouped into quarterly retirement statement packages and sent to companies who provided the retirement plans for their employees. Each company received a package containing company information sheets, bundled envelopes of individual employee retirement statements, and a

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set of prospectus booklets. About 38,000 packages were printed and distributed within a 10-day period at the end of each quarter.

Due to the complexity and tight deadlines for the job, the print production facility had undergone an earlier optimization assessment to streamline their work process. The work practice observations presented in this paper ran in parallel to a second phase of the optimization assessment, enabling the work practice team to observe the assessment team and their techniques as well as the print production facility during their normal work. This paper focuses on our study of the print production facility. We reserve the findings from our observations of the assessment team for future publication

The study provided an opportunity for all of the workers at the facility to reflect on their work and offer suggestions for improvements with assurances that the researchers would work to make sure that those suggestions were at least understood if not necessarily acted upon. In addition, researchers carefully documented the observed work practices, thus representing not only the workers' suggestions, but also the strengths and complexities of their current practices. Though the financial benefit of the improved efficiency would go primarily to owners of the facility, the secondary benefits of reducing complexity and increasing effectiveness for the workers are not negligible. Indeed, without the thorough study of the work practices from all angles, efforts to improve efficiency risk both failure from unanticipated consequences and frustration from the people who implement them. In addition, benefits accrued to the researchers' organization. The researchers are members of a group dedicated to technological innovation in print environments and the kind of detailed knowledge gained from the study was critical to innovation.

Below, we describe the print job we observed, including the physical layout of the shop, the current steps required to print the job, the paper documents used to support the job, and the roles of the people who worked on the job. We also provide some key findings and observations that were missing from management's written descriptions of the job and discuss the implications of capturing the voices of the workers.

METHODS AND PARTICIPANTS

The print facility included a wide variety of workers with different backgrounds and scopes of responsibility. The workers included managers, permanent employees and temporary employees. Managers focused on the financial aspects of the job, allocating people and machinery to tasks and managing schedules. The permanent workers operated the complex machinery such as the printers and inserters (devices for folding and stuffing documents into envelopes). The temporary workers manually sorted and bundled the printed documents.

Building relationships with the site and study participants

Our relationship with the printshop began with the positive rapport that the first assessment team established through their efforts to help decrease the complexity of the work. Before the study began, work practice researchers and members of the first assessment team held a series of meetings with the management staff to become familiar with their concerns about their work and their hopes for the study. These meetings, as well as agreements to abide by their operating rules helped form a good working relationship between the study participants and the observers.

The participants at the print production facility were actively engaged in the study. They provided open access to observe their work and were willing to explain their work when asked. During the observations, clarifying questions were asked of the workers to better understand the reasoning process used, and opinions and suggestions were openly sought. Participants from all of the job categories (management, permanent, and temporary) actively voiced areas of concern with the current process, provided historical perspectives on how the job had evolved, and shared ideas for improvements.

Work Practice Data Collection Methods

Researchers conducted open-ended interviews and observations during the course of the entire 10-day job. They observed printing, insertion of statements into envelopes, grouping of statements and prospectuses into packages, quality assurance processes, troubleshooting, and oversight activities. They also observed interactions among workers, workarounds, problem solving, schedule adjustments and load balancing.

Work Practice Data

The data collected for this study included field notes, paper forms and artifacts, and over 30 hours of video documenting every aspect of the observed job, from printing through fulfillment. Paper documents included job tickets for two file types: employee and company files, fulfillment tracking forms, envelope counting forms, and other training, labels, and record keeping forms. We also collected formal procedural descriptions of the job developed by the print facility's management, so we could compare these descriptions against the actual work practices that we observed.

We indexed and summarized the videotapes per Wall and Brun-Cottan (1995). The collected set of observation information was analyzed and used to create graphical representations of the current practices, and for highlighting issues, insights and opportunities for production work (e.g. Wall and Mosher, 1994, Woods et al, 2002).

The work practice observations were qualitative in nature. They provided real-time perspectives and insights into the dynamic, unpredictable aspects of the work that would otherwise be transparent to quantitative evaluation. The observations revealed some of the

problems encountered during the course of the 10-day job and how those problems were resolved. In addition to observations, workers' suggestions for improvements to the process and comments on the process were noted.

Analysis process

The researchers collected their field notes in a central location and viewed, transcribed and summarized the videotapes. From this material, they pieced together the overall work process and categorized findings based on the interests of the sponsors of the research activity. Sponsors included both management of the print production facility and the managers of our internal research organization, who were looking for research opportunities that might result in new service opportunities for the company. As information was processed, team members reflected on implications and asked follow-up questions on site.

We created graphical representations of the multiple branches of each step of the highly-manual process, noting extensive detail, including how the process worked, problems that were identified, and how intervention and corrections were accomplished. The representations included photographs taken at the site and illustrations of the activities that comprise the processes, supplemented by textual descriptions. We documented dependencies and problems within the overall process and included them as overlays on the workflow diagrams. See Figures 5 and 10 for examples of these representations. We also created PowerPoint summaries of potential technological improvements, as well as the potential impacts of these changes.

SUMMARY OF OBSERVATIONS

The work process for the retirement package job was based on a number of different factors, including the layout and available space for the shop, the previous printing experiences with this job and the experience of the entire staff. Here, we outline the process to give a sense of the complex constraints on the process and the techniques the print facility had developed to tame it.

FIGURE 1 –Print room (left) and Inserter room (right)

Map of print production facility layout

The print facility occupied two different rooms, with a third area for offices, meetings and some fulfillment activities (i.e., processing for mailing). The main print room contained four digital production printers (1), a computer server room (2), a shipping area (3) and a work area for fulfillment activities (4). A second room across the hall held three production inserters (5) and two postal meters (6). The second room also contained a locked area (7) storing controlled paper stock, such as serial numbered blank checks. Another stock room between the two main rooms was used for paper. This stock room was connected to a loading dock where the U.S. post office dropped off and picked up bins of completed envelopes and All Purpose Containers (APCs). The layout of the two equipment rooms can be seen in Figure 1 (illustrations created by the print facility).

FIGURE 1 - Preprinted fund guide sheets stacked in halls

FIGURE 2 - Company sheet with colored separator sheet on bottom

The Quarterly Retirement Package Work Process

The quarterly retirement package process delivered a retirement statement to employees in several different companies. Each employee got an individual employee letter, but the letter was delivered by the managers at their respective companies. Therefore, the printshop inserted individual employee letters into individual envelopes and bundled them with the retirement information provided to the company. The envelopes containing the employee letters were inserted into a larger envelope

(or occasionally a box) that was sent to the companies who distributed the letters. Sending the wrong letter to an employee or the wrong employee package to a company was a serious error that the print facility worked very hard to avoid. One technique they used to minimize the potential for this kind of error was printing a sample set of letters, called "hold files", which their customer examined to make sure no such errors had occurred.

The 10-day printing and packaging process consumed 2-3 shifts per day. The current practice, as shown in Figure 5, started when the facility received data tapes from the customers and the data was downloaded onto local servers for printing. It then split into two main paths – one for the company (labeled C files in Figure 5) and another for the employee (labeled P files in Figure 5). These two paths met further along in the process where their results were merged into large envelopes, postmarked and shipped to the Post Office for delivery.

Fund Guide Sheets. Before the main quarterly retirement statement job arrived for printing, the print facility received and printed a set of retirement fund sheets, known as guide sheets, which would later be inserted into the quarterly retirement packages. These guide sheets were stacked in paper racks in the hallways for later insertion into the quarterly print run (Figure 2). These stacks were labeled with colored sheets that indicated the appropriate retirement fund family and marked to indicate which packages would need which guide sheets (Figure 3).

The print operator split the printing of the guide sheets across the facility's four production machines. The operator checked the page counts on the device before the file started and after it finished printing, and wrote the start and end values on the job ticket. The page counts indicating the number of sheets for each file were transferred by hand to the final billing statements. The print operator also hand-wrote the sequential company identification numbers of the files on the job ticket. These company identifications numbers ensured that the sheets were kept in order in all subsequent steps in the work process.

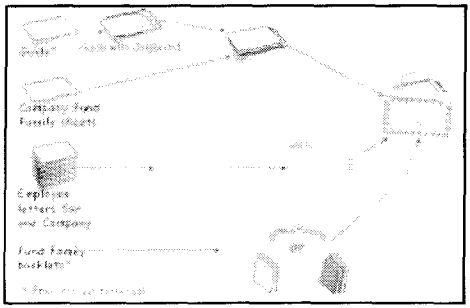

FIGURE 3 – Sample company package

Company Information Sheets. The packages that were sent to each company included company information sheets, which summarized employee quarterly retirement investments. The print facility called the files that contained the company information "C-files." The information sheets were printed from these files in batches of 300 companies. The prints for each company were separated by a colored sheet that contained the company id. To further differentiate between companies in each stack, the production facility placed the stacks and colored sheets for each company in an orientation that was offset at a 90 degree angle from the company sheets below. Once a stack of 300 company sheets was complete, the output stack was manually recounted to

ensure that sheets from different companies were not combined. Next, the appropriate fund guide sheets were inserted into sets for each company. The company sets were stabilized with chipboard and shrink-wrapped. The stacks of shrink-wrapped company bundles were kept in batches of 300 companies, each with its own paper job ticket that traveled with it.

Employee Letters. Employee Letters were the documents given to individual employees. They summarized the employees' quarterly retirement package investments. They were delivered in files called "P-files" for participant files. These letters were also printed in batches of 300 companies. The sizes of these files varied greatly because the size depended on the number of employees in the company. These file sizes were unknown until print time because no pre-processing of the files was done by the print facility, and the customer could not provide this information. Once the files were printed, the sheet counts were handwritten on the job ticket for use in quality assurance and future billing. After they were printed, the employee letters were automatically inserted into envelopes with an insertion machine, and stacked sequentially in postal letter trays. Each employee letter had a client id number above the address that was used for grouping, sequencing and matching

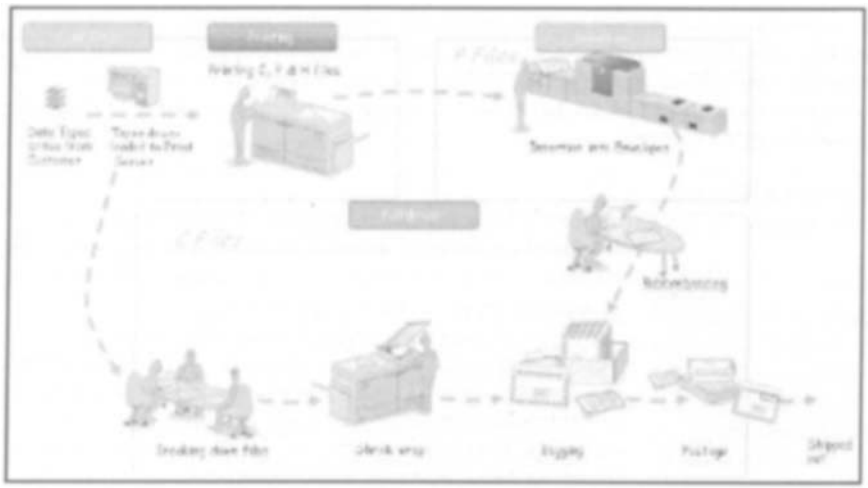

FIGURE 4 – Quarterly retirement package work process

with the company bundles. The employee letter envelopes were grouped and rubber-banded by company number and replaced in letter trays in sequential order.

Hold Files. Hold files (H files) were files designated by the customer which were printed and held apart from the rest of the job so a customer representative could review them for quality assurance.

Bagging. Once the company information sheets, printed from the C files, and the employee letters, printed from the P files, completed their paths, the temporary employees gathered batches of 300 together for merging. They did this operation at several large tables in the primary printing room.

They "bagged" a single company bundle and the corresponding set of employee letter envelopes into larger envelopes, along with any appropriate prospectus booklets that were provided by the fund families (Figure 4). They recounted all the envelopes for a given file to catch errors in the bundling process. They then sealed the large envelopes and sent them back to the insertion room where other employees weighed each envelope and manually affixed postage. The stamped envelopes were packed back into postal bins, carted to the loading dock and picked up by the post office to be shipped directly to the companies. Postage errors were noted on the job ticket to adjust the final billing statements. Figure 5 diagrams the entire process.

Document Artifacts

To support the quarterly retirement package work activities, the print facility had developed a number of different documents to monitor and track the flow of the files through the shop. Samples of the following documents can be found in Appendix A.1.

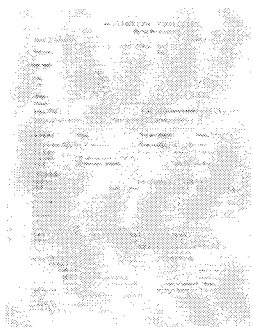

FIGURE 5 - Job Ticket

These documents are what Shalin (2005) called "representations." That is, they are lower resolution descriptions of a complex reality. Though paper based, these documents, like the representations Shalin describes, support response to anomalies. They provide a graphic representation of the state of the job so it can be altered if anomalies occur. They have the additional benefit that they are physically associated with the artifacts they describe, providing them with a deictic character.

- ***The job log (job ticket)*** was a paper document that moved through the shop with the various files. At each step in the work process, the file was checked, counts were logged by hand, and the job was signed off by the workers. Quality checks and samples that were pulled for inspection were also handwritten on the job ticket.

Manual fulfillment steps were tracked through several documents:

- ***A fulfillment status document*** listed each file and recorded the completion of each stage in the fulfillment, or bundling and packaging, process. This document was kept in

an open binder on the shop floor, for the shift manager and floor manager to monitor the job's progress. It also provided status information during shift changes.

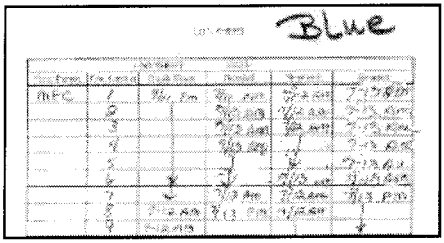

FIGURE 5 - Fulfillment status

- ***Envelope counts*** for each file were written on a form to track the counts of different sizes of envelopes used for each file. Results of quality assurance checks to maintain the correct number of clients in the file were also recorded on the same form.

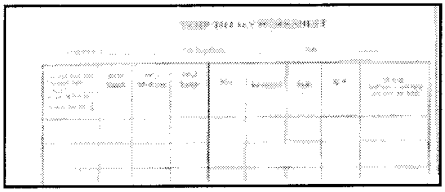

FIGURE 5 - Envelope counts

Comparison between observed workflow and documented process

As required by corporate policies, the workflow for the process was documented by the print production facility. The documentation consisted primarily of a procedural description that listed each of the activities that needed to be performed to accomplish the job. For this particular job, there were two such descriptions: one describing the printing process, the other describing the fulfillment process. The descriptions in each document are at different levels of detail. The fulfillment process, which is quite complicated in practice, is documented in only one page, whereas the print process document is seven pages. In addition to procedural descriptions, the fulfillment process also suggested the best way to accomplish specific aspects of the job.

The formal documentation created by the print facility left out important characteristics of the work. For example, as described below, anomalies arose constantly throughout the run of the job, from diverse sources such as multiple copies of a file delivered as a single file, malfunction and breakdowns of the machines, and human error such as misplaced letters. Resolving these anomalies required dynamic adjustments to the process on an ongoing basis. These adjustments were made by everyone involved in the process regardless of whether they were managing or executing the process. The type of adjustment depended on the person's job: a manager might reassign a worker or a machine; a worker might halt the process due to bad input, or stop to search for a misplaced statement.

These anomalies were unpredictable and therefore were not included in the official documentation of the process. This unpredictability, coupled with the relative rareness of each particular anomaly suggests that formal documentation of the anomalies and procedures for addressing them might not be a good use of the print facility's time and money. The cost in time and effort of writing the extensive documentation needed to deal with all anomalies, coupled with the cost of finding the right information in a large compendium of documentation is likely to be greater than the cost of dealing with the

problem in an ad hoc manner. However, one contribution of our ethnographic study was to highlight the fact that these anomalies do occur, and that any new tools or automation developed to optimize the job must include some way of dealing with them. Currently, the existence of a human in the loop allows the flexibility to create ad hoc solutions as anomalies arise. New tools could focus on facilitating the detection and response to these anomalies, in addition to making the general job processes more efficient.

Other characteristics of the work which were missing from the facility's formal documentation are listed below in our key findings section. Two of the key findings described below, dynamic scheduling and proactive troubleshooting, represent the kind of procedural knowledge that is difficult to capture in formal documentation. Dynamic scheduling requires managers to reallocate machinery and people to new tasks as anomalies occur. This rescheduling requires managers to anticipate scheduling disruptions caused by such reallocation and work within constraints such as the availability of workers. Proactive troubleshooting requires workers implementing the process to carry out activities that catch errors early. While such troubleshooting can be formalized, reactions to the errors, once caught, are necessarily more ad hoc, since each error is unique. It was seen that experience with troubleshooting these problems provided more options for the floor manager to work in more flexible ways to accomplish the work in the given time, despite the problems.

These anomalies were also important reasons why a process such as the one observed could not be fully automated, or had limits in the amount of optimization that can be achieved. Issues such as the dynamic adjustments and shifting of the work were among the findings passed on to the optimization assessment team.

Indeed, the ability to make these quotidian heroics visible is one of the values of ethnography. A smoothly running process that includes humans is likely to also involve dynamic scheduling and proactive troubleshooting. These activities tend to hide themselves because, when they are most successful, the process does not suffer. As outsiders, the ordinariness of the activities is more apparent to ethnographers, so they are able to make the activities visible, ensuring that the optimizations to the process support these necessary aspects of the work.

KEY FINDINGS

A number of key observations were found during the work practice study of the quarterly retirement package job. These observations are summarized below and focus primarily on anticipating and managing trouble in order to ensure maximum productivity

Dynamic Scheduling

Dynamic scheduling was a critical aspect of the print facility's operations, in which its management fluidly allocated resources to different aspects of the job, based on existing or

potential bottlenecks in the flow of the job. Although there was a basic plan for how the entire job should proceed, the facility's floor manager constantly monitored the progress of the job, both within and across different areas of the facility. Based on the progress of the job, adjustments were made to maximize the utilization of resources.

FIGURE 5 - Colored job tickets allowed floor manager to see status at a glance

Dynamic scheduling in the print facility was supported by the paper based representation mentioned above. Like the computer display described by Shalin (2005), these pieces of paper provided critical information about the context of the re-planning required that made such re-planning possible. The color and position of the job tickets provided a visual cue which made the paper in context with the shop layout integral to the information it provided. This information was something that the floor manager was able to ascertain knowing the shop layout and the work process. Figure 9 shows one example of such a representation. The color job tickets and their proximity to a given work station provide status information to the floor manager and enable monitoring of the job's progress in real time. For example, the job tickets shown in Figure 9 were on top of company information sheets in the main walkway of the print shop, in queue to be offset and counted by the temporary employees. The contextual knowledge needed for re-planning is knowledge of the current state, especially the goals that have been achieved. The stacks of paper with their colored cover sheets provided clear indication of what needed to be done. This knowledge could be coupled with the subtle and shifting knowledge of who was available and capable of working on the rest of the task.

The visual contextual information, provided by the location, orientation, and color of the printed sheets was a very efficient and effective way of representing the status of the job. This particular aspect of the job might be missed by engineers who plan to develop tools to optimize the job. Therefore, one of our contributions from the study was to highlight the fact that this status information was available, and was an important element in the work of the shop floor manager. Therefore, any new tools that are developed will need to include some form of status information which is available to the shop floor manager at a glance.

As an example of dynamic scheduling, we observed several instances in which the shop manager reallocated people and equipment, both in anticipation of potential problems, and to work around problems that had already arisen. As mentioned above, after files were printed, workers separated the printed data stream into bundles that would be sent to specific companies. They did this by stacking the pages for each company in a different orientation (i.e., offsetting each set of prints), and placing a color coded sheet between the pages for each company. (See Figure 3) They called this process "breaking-down" the files. As the number of broken down files increased, a second available shrink wrap machine was

brought online to handle the surplus of broken down files. The increasing number and size of the stack provided the cue that led to additional shrink wrapping.

In another instance, the automatic inserter machines stopped working for a period of time. These machines are used to automatically insert employee letters into envelopes. Once the inserters were fixed, more people were shifted to the task of placing rubber bands around collections of envelopes to manage the surplus produced by the automatic inserters. Here, the stacks of filled envelopes provided the contextual knowledge that indicated a need for more workers to add rubber bands.

In a third instance, the floor manager began to notice a bottleneck in the shrink-wrapping stage of the job. As a workaround, the floor manager brought in workers for an extra shift to focus on shrink wrapping. This extra shift enabled the contract workers to place envelopes into bags the following day. Again, the stacks of artifacts indicated the need for more work.

This kind of dynamic scheduling, in which people and resources are fluidly re-allocated based on current and predicted problems with the job, is very difficult, if not impossible, to represent in a standard procedural description like the one developed by the print facility's management. This characteristic of the work was indeed missing from the procedural description of the quarterly retirement package job. However, it is the fluid, adaptable nature of the scheduling and resource allocation that was essential to getting the job printed in the tight timeframe that was required. The proactive aspect of the dynamic scheduling activities can be difficult to implement in an automated scheduling program. However, the entire job could shut down in response to anomalies like machine failures if management attempted to automate job scheduling without realizing that the dynamic scheduling helped to accommodate the anomalies, reducing their risks and contributing greatly to the success of the job. This proactive characteristic of dynamic scheduling is indicative of a more general proactive troubleshooting trend that we observed throughout the run of the print job. It is similar to other work processes that deal with anomalies that we've observed in other print shops and in studies of office work. Also see Bowers et al (1995) regarding observations of work in production print environments.

Proactive Troubleshooting

Throughout the job that we observed, all members of the production staff were on the lookout for potential problems in an effort to intercept problems before they became major issues. We observed one print operator detect a defective print file that contained 3 copies of the given file instead of one. He caught this problem by checking the computer screen to monitor the percent completed of the job and by noticing that the total number of printed pages was significantly larger than it was for typical files. Another print operator identified a graphic alignment issue early in the print run by routinely checking the printed output. These problems required the print production facility to stop printing the file and request that new files be sent to the production facility.

The fulfillment team also demonstrated instances of proactive troubleshooting. They checked for, and fixed, several unsealed inserted envelopes. They also detected, and corrected a serious error in which two different client statements had been combined into a single shrink wrapped packet. Due to their proactive checking, this problem was resolved before the statements proceeded to the final bagging stage of the job.

Critical process know-how and proactive troubleshooting such as the observed undocumented actions were highly valued by the print facility because job integrity of 100 percent was critical for this financial job. Therefore, the need for job integrity was emphasized in all departments. For example, this kind of troubleshooting was part of the verbal orientation received by the temporary employees doing the manual fulfillment steps, though it was not mentioned in the written documentation. The temporary employees were instructed that if they had any questions or noticed any inconsistencies, they should immediately escalate them to the shift manager for resolution. The shift manager had the authority to redirect workers or work to keep the job moving.

Proactive troubleshooting was also built into formal processes. Daily shift handoff meetings were held to facilitate a smooth transition between shifts. These were brief meetings at the beginning of the morning shift, so the night shift could provide a quick update on the progress of the job and any problems that may affect the workplan for that day.

Another example of proactive troubleshooting happened at the end of every quarterly job. The permanent staff held a post mortem meeting to discuss any potential improvements to the process. These meetings brought about improvements and suggestions that were investigated with the customer for future jobs. A list of suggestions was created and those that required customer assistance were reviewed with the customer. Others were assigned to champions and tracked throughout the year. Those changes that affected the work process caused updates to the documentation as time allowed. Temporary employees were gone when this meeting was held, creating a gap in the discussion that the work practice research team was able to bridge during their study.

The use of proactive troubleshooting, even when everything was running smoothly, is similar to other domains like space shuttle mission control, in which operators routinely monitor an ongoing process with the goal of predicting, or detecting any problems before they escalate out of control (e.g. Watts et al, 1996, Woods, 1994, Woods and Patterson, 2001). Proactive troubleshooting activities are instrumental in facilitating a successful completion of the job. As with dynamic scheduling, these kinds of activities were not formally represented in the procedural descriptions that the print facility's management used to document the workflow of the job. However, it is important to maintain, or at least facilitate the continuation of proactive troubleshooting in any tools or automated processes that are implemented to streamline the job.

Role of paper-based tracking/communication mechanisms

We observed that paper-based tracking and communication related to print jobs were central to operations at the print facility. Paper forms were designed by the print facility team and were used throughout the workflow. The paper job ticket traveled with the job to track status, page counts and quality assurance checks. A color-coordinated job ticket, fund file, fulfillment tracking forms, separator sheets, and matching labels were used to track the usage of different versions of files throughout the process. In fulfillment, forms were used to track the envelope counts for each file. The print facility also used paper forms to track the status, and monitor progress of each fund family, consisting of multiple client files, as it moved throughout the print facility. The color coding of the paper documents and their location in the shop provided a visual status of the process, available at a glance from a distance. In designing tools and processes to streamline this print job, it will be important to maintain the tracking and status functions that the paper documents provided as the job moved throughout the shop.

Here, the physical nature of the paper had advantages. Because it is physical, it does not need to be turned on to be queried giving the floor manager a continuous sense of what was going on, on the floor. Its physicality also meant that it moved with the stacks of paper it was on without additional activity. Because it is inexpensive, many pieces of paper could be used to support the process. Because it is markable, notes on unexpected events could be added to it helping to make sense of those events.

Incorporating workarounds into standard practice

The dynamic scheduling, proactive troubleshooting, and workarounds described above were implemented on an ad hoc basis as the need arose throughout the run of the print job. There were other problems that occurred regularly whenever the job was run. These recurring problems were formally identified by the print facility team, and procedures were written to address the problems whenever they arose. For example, one recurring problem was when the count that was performed during file

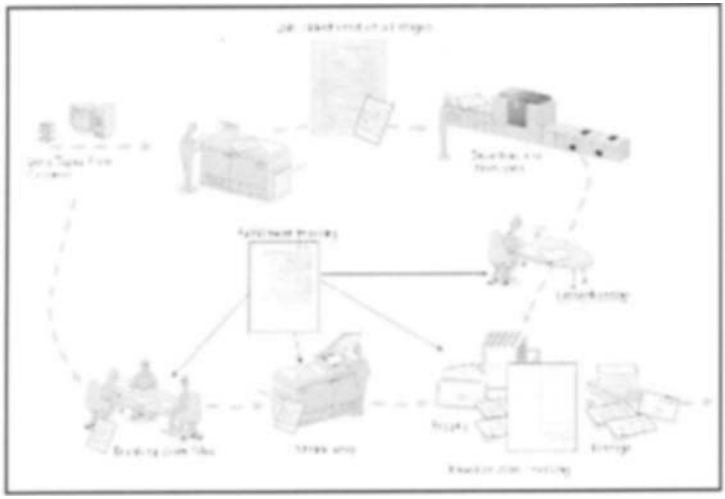

FIGURE 10 - Documents used in the work process

breakdown did not match the expected number. The procedure implemented by the shop to handle this kind of problem was to re-inspect and re-count the file to find the error. Another procedure that was implemented to avoid recurring problems was to count envelopes before sealing them, in an effort to find any double-stuffed envelopes. This procedure was performed before the envelopes were sealed, so that re-bagging would not be necessary. Another procedure implemented by the print facility team was to log postage adjustments such as double postage or bad postage on the job ticket, to aid the task of balancing the books at the end of the job.

By formalizing these workarounds and creating specific procedures for recurring problems, the print facility was able to respond efficiently and effectively whenever the predicted problems appeared. Here, the formalization was possible because the problems occurred several times, and were expected to continue to recur. Truly unanticipated problems will still require ad hoc solutions.

OPPORTUNITIES AND EXAMPLES OF IMPROVING CURRENT PRACTICES

The retirement plan package job is unique for this print facility in terms of the quantity and complexity of the output and the resources required to complete the job. It stresses the resources of the print facility and was selected for our observation because the management was interested in suggestions for improvements. In our initial interviews with the staff, as they described the job in terms of their roles and perspectives, we were told repeatedly that the job was difficult to describe and that we had to see it to understand it. This section discusses some of the opportunities and examples for improving the current practices for the retirement plan print job.

Applying paper-based tools to a broader base of jobs

The development of paper-based tracking and communication tools was discussed earlier. A series of document-based tools in the form of checklists, logs and charts was created by various individuals over the course of successive quarters and inserted in critical points in the process. These tools enabled the staff to better manage, track, communicate job progress, and enable smooth transitions across shifts. This portfolio of documents could potentially provide the basis for a set of tools that could be applied to other jobs.

Proposed changes in the structure of files

The electronic data files, created by the client and delivered on tape to the production facility, were structured as data streams rather than document files. One implication of this was that the print facility workers could not determine the file size, specifically the number of images in a file, prior to printing the file. This uncertainty resulted in the need to manually calculate the number of prints and record it on the job ticket. Since any changes to the file structure would require programming level changes by the client's IT team, this change

required negotiation with the customer. At the time of the conclusion of this study, the customer had not agreed to implement the suggested file structure improvements. This example illustrates the interplay and dependence of the print facility on the customer to provide files in such a way that the print facility can cost effectively complete the job. These kinds of activities, in particular the negotiation and articulation of critical handoffs, were not accounted for in any of the formal process documentation. For more discussion on the asymmetrically collaborative relationship between printshops and their customers, see O'Neill et al (2007).

Despite identified opportunities for improvement of the process, not all improvements were possible to be implemented as shown above. The print facility did not have control of the format of the data input and that put constraints on how the data could be handled. Such adjustments were not always ideal, but it provides a view on how external factors can affect a work process.

Potential Technology Interventions

There were several occasions where staff indicated that the introduction of a technology solution to streamline the process would be welcome.

One example concerns the job tickets which were manually logged with meter counts, client numbers and quality assurance at every stage. The data from the job tickets were manually transferred into an electronic spreadsheet to record the costs of the job and to prepare the customer's bill. Suggestions for more automated ways to capture the print counts for billing purposes were discussed and have been investigated both by the research group and the print shop.

The practices described above represent a level of detail that is not captured in the formal process descriptions of the print facility. It was through our observations and interactions with the workers across the entire cycle of the job that resulted in the identification and confirmation that these would be beneficial to the job and the people responsible for the work. At the conclusion of the study, we shared our findings with the print facility managers and the workers. We described our observations about current work practices, using this as an opportunity to solicit clarification and corrections to our representations. We also presented a range of suggestions for improvements and discussed potential next steps to pursue the highest priority suggestions.

DISCUSSION AND CONCLUSIONS

This paper describes an ethnographic study of a complex, labor-intensive print job in a digital print production facility in order to inform the development of tools, processes and technologies that could potentially improve this kind of job within the print production facility. We discovered several techniques that workers used to insure that this complicated

job ran smoothly, including dynamic scheduling, proactive troubleshooting, the role of paper based communications and the incorporation of workarounds into their standard practices. These activities were not visible within the formalized descriptions used by the print facility to document their procedures. Although management was aware of many of the things we observed, such as dynamic scheduling, other work practices such as proactive troubleshooting were less visible. Our study articulated these practices in a way that could be shared and recognized. It also raised the awareness that any innovations or improvements need to carefully fit with and support existing practices and not undo what is already working. In this way our work represented the voices of the workers, which were not previously documented in the formalized workflows familiar to the print facility's management. These findings represented the voices and current work practices of a broad cross section of the workers whose voices, though not silenced, were not available in an organized fashion, or in a way that would contribute to the development of new tools or more efficient workflow designs.

Project findings also represented the voices of the workers to research teams who are looking at ways to automate and streamline the print facility's operations. Many of the workers' comments would never have been heard by research teams through any other methodology. It emphasizes the important roles that people played as part of their work practices and how their own tacit knowledge can impact the work. Improvements to such a manual work process can certainly be made, but it is still up to the human in the process to make the judgment call on how best to intervene when a problem occurs.

In this study the value of people in the quarterly retirement work process became apparent in the observations surrounding dynamic scheduling and proactive trouble shooting. Not only do people possess the ability to address problems and situations when they arise, but people have the ability to understand when such adjustments are necessary and when the system can operate without intervention. The contribution of our ethnographic study was to highlight elements of the complex printing workflow where people were detecting and creating solutions to a wide variety of unexpected problems on an ad-hoc basis. These findings can guide the development of more successful technologies to optimize the process by showing the types of problem-solving skills that are necessary for the job, and by highlighting areas where the skills of the human workers can compliment any automation that is developed.

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