The Micro Traveler and the Hero's Journey

Shared Narratives and the Design of a Collaborative Work Environment

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ABSTRACT

Narrative representations, such as use-cases have grown increasingly popular in software design. User stories can do more than describe system behavior in a coherent sequential form: the stories users tell also can help designers understand the changing structures of relationship and meaning through which they think about their practice, goals and technology. Indeed, we can think of software design as a process of revealing the stories implicit in a community of practice. This paper examines the narrative forms we uncovered in the design of a collaborative information management system for a community of micro-mechanical systems engineers, and describes their effect on system design.

Keywords

Interaction design, field methods, narrative

INTRODUCTION

Although understanding the narratives that members of a community jointly create to think about themselves, their work and technology is a powerful tool, the relationship of user narratives to the design process is far from simple. By its nature, software design makes explicit many aspects of a community's knowledge, values and relationships that would otherwise remain implied. By formalizing information, work procedures and communication, the design process often reveals latent tensions between conflicting expectations, assumptions and narrative points of view. As designers we must resolve these tensions, both through the artifacts we build, and through our participation in the social processes surrounding their design and adoption.

This paper examines the user narratives we revealed in designing a collaborative information management system for a group of microsystems scientists and engineers at Sandia National Laboratories.

Our program automates the documents (called *travelers* because they "follow" a part through its fabrication) used to record process information for a micro-mechanical fabrication process known as LIGA (defined below). In designing this software, we made a special effort to understand the narrative patterns through which our users thought about their goals, practice and information technology.

This paper begins with an overview of the function of narrative in socially situated cognition, paying particular attention to its role in explaining and reasoning about cultural change. It then examines the relationship between narrative and software design. The next section provides an overview of the Traveler System, defining the problem we aimed to solve and the software we built. The remainder of the paper looks at the two primary narrative schemes our fieldwork encountered in discussions of the proposed system. The first is a form of unity narrative that looked to our software to bring the user community together around the task of taking the LIGA process out of R&D and into mature production use. The second set of stories followed the pattern of the hero's journey story, and emphasized the individual user's struggles in moving toward this end. We then examine the influence of these narratives on system design, and the way our efforts revealed the deeper tensions between these points of view.

NARRATIVE, CULTURE AND CHANGE

The ability, or perhaps more accurately, the need to organize our knowledge and experience in a narrative form is one of the central characteristics of human intelligence [2-4]. We are unique, both in our ability to form narratives, and in the degree to which we rely upon them to organize our knowledge of the world and our place in it. Artificial Intelligence has recognized the importance of narrative structure since its earliest days [5]. More recent work has demonstrated the role of narrative in the formation of scientific theories [6, 7], in governing human-computer interaction [8], in our conceptions of virtual environments [9], and in our understanding of information technology itself [10].

For example, Landau [7] has shown how a common narrative structure unified differing formulations of the theory of evolution in its early development. These different formulations all follow the form of the hero's journey story [11, 12], in which our evolutionary predecessors assumed the role of the hero, a significant genetic change (encephalization, bipedalism, language) is the hero's gift, and the resulting struggle for survival became the hero's journey. Landau does not suggest that these narrative structures displace the essential scientific activities of experiment and theoretical analysis. Rather, she demonstrates how the hero narrative provided a common framework for debates over alternative forms of evolutionary theory, placing the major issues of the developing theory in a common context that assured comparability and supported purposeful analysis.

Coyne [10] has shown how unity narratives shape our understanding of information technology [IT], and its application. His deconstruction of the stories we use to understand IT, cyberspace and the social effects of computers traces their origins to the romantic and rationalist traditions of the eighteenth and nineteenth centuries. Coyne argues that such themes as virtual communities, immersive environments and the belief that cyberspace transcends traditional laws of biology, economics and culture rests on an odd combination of rationalism's faith in reason and science, and romanticism's belief in the primacy of the individual and subjective judgment. Many discussions of IT speak of its ability to create human communities that transcend distance, while simultaneously giving form to our most individual, subjective fantasies [17]. Coyne argues that moving past uncritical unity narratives allows designers to ground their efforts in a systematic understanding of culture, cognition and practice.

What is most interesting to us as software developers is the role of narrative in explaining change. Bruner [2] has argued that although accepted social norms are embodied as rules and lack explicit narrative structure, narrative formulations become important in explaining departures from these norms. Narrative contributes to thinking as a tool for reasoning about disruptions, novelty and change. It is not accidental that both Coyne and Landau look at narrative's role in the early stages of a technology's or theory's development: stories seem less important in the case of mature sciences like physics or chemistry. Similarly, understanding user narratives is particularly useful in managing the changes that accompany introduction of a new software system into a user community

This function of narrative in explaining the unusual makes it a powerful tool for understanding people's hopes for a software system, their concerns about its impact on their work, and potential obstacles to its deployment. User narratives can help us to understand the deeper, changing patterns of meaning people share within a community, and to design software that engages people at this basic level. At the same time, we must recognize the contingent, situated nature of user stories, and balance them against a more scientific understanding of cognition, work practice and the structure of human community.

NARRATIVES AND SOFTWARE DESIGN

In the last part of the twentieth century, thinking about the way humans create and share meaning has shifted from correspondence theories of semantics (where symbols refer to facts or entities in an objective, external world), to structural theories, which view meaning as accruing from interactions across systems of concepts and relations (see [10] for an overview of structuralism that focuses on its relevance to software design). These systems of meaning are embodied in both the structure of language and in the public artifacts and activities of culture. One consequence of structural theories is the recognition that meaning relies on interpretation and action within specific situations, rather than the composition of independent facts to describe objective situations. Another consequence of structuralism is recognition of the role of metaphor, analogy and stories in linguistic meaning. The ability of narrative to capture complex meanings in coherent structures makes it an ideal tool for modeling the systems of thought users bring to their work. Narratives have many qualities that explain their usefulness to software designers [4, 13], including:

• **Narrative Diachronicity**. Rather than focus on individual events, narratives describe how events interact over time. This ability to place complex patterns of events in a coherent system of causes and results is particularly useful for interaction designers, and explains the popularity of narrative-based approaches such as use-cases, scenarios [14] and user stories. Attention to narrative structure in interaction design can help us avoid the ambiguity, error and dead-end interactions that plague so much software. By attending to such rhetorical qualities as closure, cycles of tension and release, and dramatic structure, we can better design programs that users will find engaging, learnable and productive [8].

• **Particularity**. People do not tell general, abstract stories. They tell stories about particular people in particular situations. Similarly, designers do not build general systems. They build systems that present the user with specific arrangements of screen components of specific colors, shapes and meaning to accomplish specific goals. The particularity of narratives counters the often-excessive abstraction of software requirements. Such tools as use-cases provide a bridge between the concreteness of human-computer interactions and the general structures of well-designed software.

• **Intentional State Entailment**. Actors in a story are not primarily important for their actions, but rather for the motives behind their behavior. This property of narrative is important to software design, since it allows us to reason about users' motives for using a program, and design software that will engage their values and goals. In our own fieldwork and informal conversations with users, we have found the stories they tell us to be useful vehicles for understanding their practice, goals and plans for the system.

• **Hermeneutic Composability**. The meaning of a narrative as a whole accrues from the interaction of its parts, but the meaning of any single part of a story depends upon its place in the broader context. This circularity mirrors the processes through which human communities negotiate meaning, as has been described in the branch of philosophy known as hermeneutics [18]. Communities arrive at shared understandings through an ongoing process of resolving this tension between context and particulars. This process is also a fundamental driver of the design lifecycle. By mirroring this interpretive cycle, narrative methods can help us reason about change, from the continuing evolution of a user community's own practice to such problems as changing requirements and potential misinterpretation of a design's intent.

• **Canonicity and Breach**. Stories describe events that violate the normal order of things, such as crises, discoveries or journeys. A software development effort inevitably places stress on the user community's norms of practice. As users respond to introduction of a new system, particularly in prototyping methods, their reactions generally take the form of stories. Narrative approaches can help designers and users anticipate software's impact on the political and economic relationships within the user community [15]. They can also help anticipate obstacles to system acceptance.

• **Normativeness**. The shape of narrative is driven by an audience's conventional expectations about their form and behavior. The best illustration of this is genre fiction: it exploits user expectations, stringing together sequences of stereotypic events until deliberately violating them to create surprise, or drive home a point. Insight into user expectations and stereotypes can help designers enhance usability, reduce errors and make systems easier to learn. Understanding narrative norms is a powerful tool for doing this.

• **Context Sensitivity and Negotiability**. The meaning of a story is not "inside" the story, but results from its interpretation by audience and author. Narratives do not construct complex meanings out of simple facts; rather they define the meaning of "facts" through their use in the story. This process of meaning construction is a negotiation between reader and text. The meaning of a computer program results from a similar negotiation. As designers, we do not simply "capture" user knowledge in a computer program; rather, we are participants in this social process of meaning creation. Understanding a user community's shared narratives helps us manage this participation.

The common thread in this analysis of narrative and software design draws on its ability to make explicit the patterns of meaning surrounding work, and the processes through which a community adopts new technology. We are not suggesting users consciously instantiate such narrative patterns as the hero story. Rather, we believe the narrative structures that have proven durable over time reflect deeply ingrained, coherent, broadly applicable systems of thinking about action and consequence that have evolved in human culture [12]. Narratives are a tool for modeling the systems of thought implicit in communities of practice. As such, they are a powerful tool for helping designers bridge the gap between implicit user practices and the formal demands of software.

Computer programs are unique among designed objects in their ability to participate in the processes through which people negotiate meaning. Recent years have seen a growing recognition of the relationship between design and the social construction of meaning [10, 14-16]. Successful programs must do more than satisfy a requirement. They must situate themselves in the field of human actions, goals and values. In our experience, most software development projects do not fail for technical reasons. They fail because they do not engage users at the fundamental level of value, meaning and practice. They solve the wrong problem, or fail to support deeper patterns of work and social interaction. By revealing the dynamic structure of meaning creation in a community, narrative methods can provide a powerful antidote to these problems.

A common error in the application of story-based methods (such as use-cases) is to use them simply to describe sequences of commands and responses, rather than to capture these deeper patterns of value, relationship and practice. Often, use-cases ignore goals, assumptions, culture and context, and turn out to be little more than conventional requirements written in story form. If designers are to derive benefit from narrative methods, we must recognize user stories as manifestations of a community's ongoing negotiations of meaning and value.

An example of an issue that is often overlooked in software design methods is the problem of multiple points of view. Generally, designers strive to develop a set of use-cases that represent a single unified view of a proposed system behavior. In contrast, human communities host multiple, often conflicting points of view, especially about work, technology and practice. A software system cannot impose a single way of thinking on something so robust as a human community. Rather, it represents one point of

view among many. Proper analysis of user narratives should reveal these different points of view, and help designers to think about their common resolution in a proposed computer program.

OVERVIEW OF THE LIGA TRAVELER SYSTEM

LIGA (an acronym for the German words for lithography, electroplating, and molding) is a micro-machining technology that originated in the early 1980s at the Karlsruhe Nuclear Research Center. LIGA involves the creation of micro-molds capable of very small (on the order of tens of microns) feature size, and the electrodeposition of metal into the mold cavity to form parts. A greatly simplified description of the process involves the following stages:

1. Substrate preparation. A sheet of Plexiglas is cemented to a wafer of conductive metal.

2. Gold mask application. A gold mask is applied to the Plexiglas sheet. The patterns in the mask will determine the shape of the molds (figure 1).

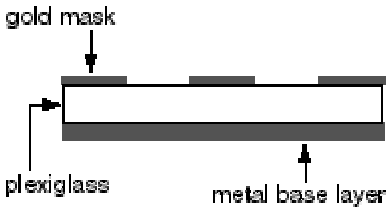

Figure 1

3. X-ray exposure. The masked substrate is bombarded with high energy x-rays. These x-rays cannot penetrate the gold mask, but do pass through the Plexiglas where the mask is missing, breaking down the polymers in those regions (figure 2).

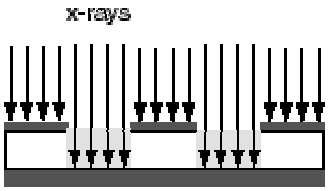

Figure 2

4. Development. Chemical baths are used to dissolve the exposed Plexiglas. The unexposed areas are unaffected. This creates a set of molds in shapes determined by the mask. (Figure 3).

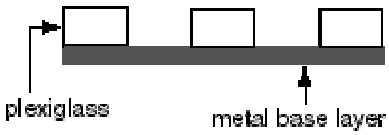

Figure 3

5. Electroplating. Metal is electrodeposited into the Plexiglas molds (figure 4).

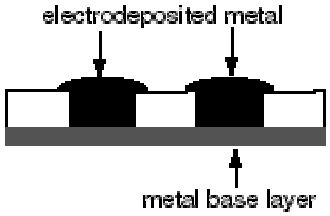

Figure 4

6. Planarization. A lapping machine smoothes the top of the electrodeposited material so the final parts will be flat on the top and bottom.

7. Release. The remaining Plexiglas is dissolved in additional chemical baths and parts are separated from the metal substrate.

Figure 5 shows a finished LIGA part for a miniature electric motor alongside a common penny.

Figure 5

Sandia's LIGA program involves the design, development and fabrication of high aspect ratio micro-machines for a variety of applications. LIGA design is done at Sandia, New Mexico while fabrication is done at Sandia, California, using DOE owned synchrotron sources. The in-house capabilities include mask layout, mask fabrication, substrate and x-ray resist preparation, x-ray resist development, high aspect ratio electroplating, lapping, and release. The x-ray exposure step is done at the Stanford Synchrotron Radiation Laboratory (SSRL) or at the Advanced Light Source (ALS) at Lawrence Berkeley National Laboratory. LIGA is one of the microsystems technology areas supported by the *Microsystems and Engineering Sciences Applications* [MESA] program at Sandia Laboratories. Our own work was funded by MESA to help create a common, web-based information infrastructure for microsystems information. As part of our MESA initiative, the Traveler project was intended to bring a diverse community of scientists, engineers and technologists together to create a well-understood set of processes for LIGA manufacture.

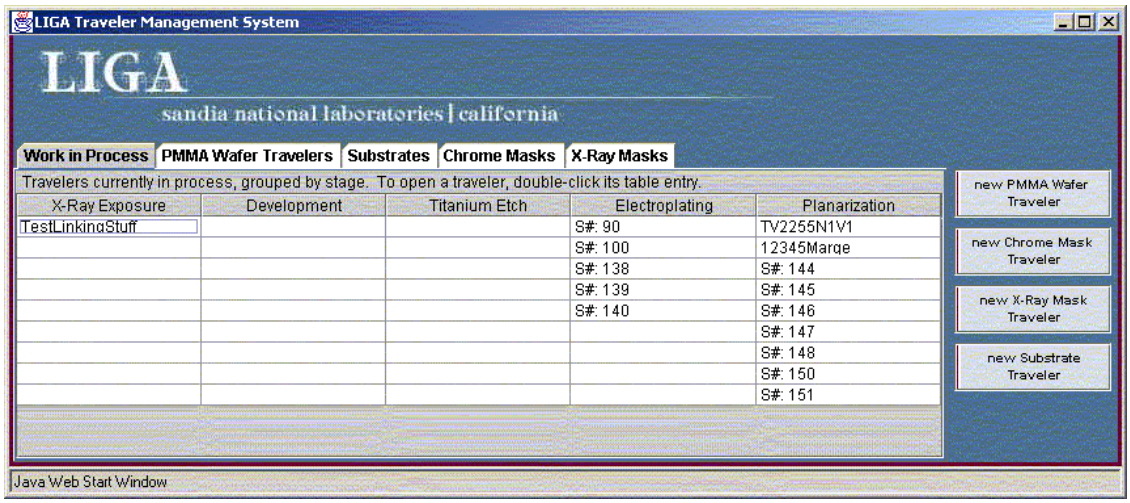

Figure 6

The importance of this explicit set of processes stems from the fact that while the research for LIGA manufacture is being developed at Sandia, California, the technology will be transferred to DOE's Kansas City Plant for production.

The history of LIGA process travelers began several years ago with engineers and scientists recording their production processes on preprinted forms. Separate paper travelers were used for each stage of fabrication. When a wafer completed its fabrication steps, all the travelers were compiled into a brown folder. These folders then resided in one of several offices. The manufacturing community soon realized that this was an unwieldy process and it was becoming increasingly cumbersome to track down and review a series of paper travelers during subsequent production runs. In addition, the pressure to transfer the manufacturing processes to a production facility, the need to repeat successful part production to support design engineers and an increased interest in a variety of LIGA applications resulted in the first automation effort.

This was a general traveler system that intended to be applicable to any manufacturing process. This html and cgi-based system was composed of three parts, an electronic order form, traveler and document manager. In addition, the system was tied to several other network-based corporate process planning, progress tracking and data archiving tools. Several features were added to the system such as saving Travelers as documents rather than storing the individual information attributes in order to facilitate "dynamic document" creation and the use of "Sets" to segregate and manage documents groups. The combination of rarely used features, dependencies on often out-dated corporate systems, navigation problems and tight controls on work-flow, forced the early demise of the system. The LIGA community eventually returned to the paper-based Traveler system.

Our Traveler System is a Java application, delivered over the web using a tool called Java Webstart. It communicates with Java Servlets using http, and these in turn, store traveler data in an SQL-Server database. In designing our system, we focused on understanding the user's expectations, on enhancing usability and on tailoring the system to their work processes. The result is a system that reflects the specific LIGA fabrication processes.

Figure 6 shows an initial work-in-process screen. This screen allows browsing of travelers in the database, and groups them by processing stage. Their design was influenced by the need to view all work-in-process, completed and scrapped wafers during the LIGA team meetings. Other tab-panes allowed users to browse different Traveler categories (Work in process, archived travelers, Substrate, Chrome Mask and X-Ray Mask). Filters and sorting assist in locating individual Travelers.

Simple navigation through the system was primary design goal. Each page of the Traveler is accessible by the click of a tab pane (Figure 7) and any supporting Traveler (masks and substrates) may be displayed by a button click. In addition, any user can access any Traveler through the work-in-process screens.

Based on our fieldwork, we avoided explicit workflow constraints or predefined controls on the sequence of processing stages. Although these stages are well ordered, we felt it important to leave control of the processes with the users. Instead, each Traveler automatically infers the stage of processing from the data entered, while allowing users to override the stage at any time. Other user requested features include embedded tables for maintaining series of steps within each processing stage, the ability to attach drawings and photographs, to annotate regions of attached images, and to generate reports.

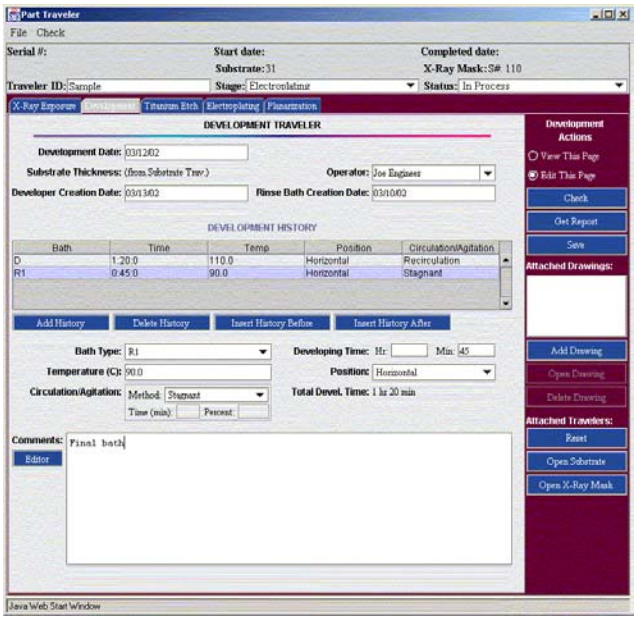

Figure 7

UNITY NARRATIVES VS THE HERO'S JOURNEY

In the course of the Traveler project, we uncovered two very different, often conflicting systems of thought that people brought to discussions of the proposed system. These conformed to two basic narrative schemes.

One point of view about the system's use took the form of the unity narrative that Coyne [10] has shown to be influential in shaping our modern understanding of information technology. Coyne traces many of our attitudes toward IT to nineteenth century romanticism, which was in many ways a reaction to the fragmentation of knowledge by science, and the breakdown of community in industrial society. Romanticism's response was to assert a deeper unity between individuals, between humans and nature, between the personal and the universal. It sought this unity in the subjective visions of individual poets and artists. Similarly, narratives of digital unity emphasize IT's potential for creating online community that transcends bounds of distance, physicality and even of the self [17]. The assertion that avatars in a virtual environment can effectively replace face-to-face contact across distances is an example of a digital unity narrative. Amazon.com's effort to create a community of customers by having it's website configure itself according to each customer's past purchases is another. The "semantic web" similarly proposes to unify all knowledge under a single ontology.

Our early experiences with our customers and users revealed the influence of unity narratives. Indeed, our own project is part of larger effort at Sandia National Laboratories to bring the diverse technologies and sciences surrounding micro-mechanical systems development together in a single location. A primary goal of the *Microsystems and Engineering Sciences Applications* [MESA] program is the construction of a set of buildings to co-locate these different specialties.

MESA funded us with the goal of creating a common information infrastructure to make microsystems information easily available on the web. Indeed, one of the authors of this paper has used, and continues to use the phrase "MESA without mortar" to describe our project goals of unifying information and human community. Our own work also reflects the scheme of unity narratives. The goal of the traveler project was to bring a diverse community together to create a single archive for the diverse information created during LIGA fabrication.

In the course of early design and fieldwork, we uncovered a very different set of narrative structures in people's thinking about their work and the proposed system. Our fieldwork included interviews where users explained their work processes and their expectations of the system, as well as observations of work in the LIGA development lab. Because we had an extremely small user community (less than a dozen people), we were able to talk to every prospective user. We also looked at the information artifacts they employed, including an earlier, paper-based traveler system. This part of our work drew on distributed cognition analysis [19]. Finally, we observed both the work of individuals and the interactions in team meetings. We interpreted these results through informal discussions, through use-case analysis and the development and evaluation of screen-only prototype systems.

In the course of this more detailed work, we found that the individuals working at the various stations of the LIGA process shared the goal of a standardized, validated set of processes, but talked about the problems of reaching that goal in terms of their own needs and concerns. These alternative viewpoints, while differing in their interpretation of problems and needs, all followed the narrative scheme of the hero's journey story [11, 12], where each person explicitly linked the success of the broader effort to their individual efforts. As in the classic hero story, these narratives began with the hero in a state of equilibrium: they simply did their jobs. This state was disrupted by a challenge: the need to take LIGA processes out of R&D and into production. Consequently, the well being of the broader community became bound to the success of the hero's journey. The hero also received a gift they hoped would help them in their quest: from the beginning users expected that our system would play a central role in this journey. The hero's journey was the path from R&D to production.

These "hero's journey" stories were better suited to describing the difficulties facing the project than the initial unity narratives. They helped us to understand the problems facing individual users and revealed the differing points of view in that community. They made the unique needs of

different stages of the process (mask design, electroplating, development, etc.) more evident than the unity narratives from the project's early stages. Variations on the hero story captured the differing points of view toward our efforts and the broader problems of maturing the LIGA process. Many users freely expressed their doubts as to the possibility of success for the project, while many regretted the failure of the earlier efforts. Both of these perspectives proved a sobering "reality check" for the design team. At the same time, the hero story gave us a common framework for thinking about these differences.

EFFECTS OF THESE NARRATIVES ON SYSTEM DESIGN

To a large extent, we can think of our design effort as moving from a simplistic interpretation of unity themes in our requirements, to a more realistic understanding of them in the context of user practice and goals. Coyne [10] has argued that thinking of IT in terms of dominant unity narratives can interfere with more a practice oriented, situated understanding of user needs. Our own experience confirms this. Arguably, the automated traveler system that preceded our own efforts was too much influenced by a belief in software's ability to unify work in an organization. It tried to provide a single framework for all types of manufacturing traveler. It linked to a number of corporate databases and document management systems in a further effort to unify information. We believe this was a source of many user complaints about usability. For example, navigation in the earlier system was difficult, since it could not take advantage of the semantic structure of a particular fabrication process. Because it tried to tie together so many different information sources, it was hard to maintain. Its automatic notification features often tended to be a nuisance, sending e-mail announcements to subscribers in response to every routine access. This sometimes caused unwanted side effects to system interactions.

In addressing these usability problems, we decided to build a system that was tailored both to the specific processes of LIGA design, and the social structures of our own user community. This led us to look for alternative ways individuals thought about the problem of capturing data on their fabrication processes, and the ability of our system to contribute.

This is not to say that unity themes are inherently wrong. Software does have potential for tying together information sources and human communities. We must be careful, however, to moderate unity themes with an empirical understanding of user work practice. Much of the power of the unity narratives is in their ability to capture a system's goals in a coherent, focused form that we could communicate with our users. This gave us a common starting point for the design, as well as shared goals. As the design effort uncovered the different points of view in the hero's journey stories, we were able to refine these common goals and place software's contribution to the unification of LIGA processes in a more realistic context.

One of the first decisions we made in our design was to avoid a workflow approach, or anything else that would limit the user's freedom, or contradict their own sense of responsibility for the outcome. One of the options our we and our customer considered in the early stages of the effort was to use a commercial product, the FactoryWorks Manufacturing Execution System [MES], to control LIGA processing. At the time we started our project, FactoryWorks was being introduced in Sandia's microchip fabrication facility. Like other MES tools, it emphasizes the control and tracking of well-defined manufacturing processes. The main reason our customer did not want to use FactoryWorks was that LIGA was still in R & D: the processes were not well enough defined to benefit from the rigorous controls an MES system provides. Rather, our system was intended to help people gather the data they needed to define these processes.

This decision was supported by both of the narrative schemes we found in our fieldwork. A significant factor the hero narratives revealed was the intense personal responsibility each of the scientists and engineers took for the development of the LIGA process. This ethos of individual responsibility was both a source of commitment that our customer wanted to preserve, and an obstacle to creating a set of well-defined practices. From the start, our customer's unity narrative, while carrying a pressure to remove LIGA from its reliance on individual skills to a more formal approach, recognized the importance of respecting the lines of responsibility and commitment in the LIGA community. Consequently, our system imposes no rigid order on of processing steps, but relies on individual users to monitor their own activities. However, our system did impose considerable rigor on the form and content of publicly shared data. This data focus was less disruptive than a direct control of processes. An example of our approach to implementing this flexibility was in the way the system tracked wafers through the process. We provided an automatic advance of processing stage when the user entered data about that stage, but did not enforce this order like an MES system. Users could override the automatic advance if they so desired.

Another important design decision that addressed the tension between these two narrative schemes concerned the browsing interface to the database of archived travelers. One set of screens allowed users to scroll through lists of all stored travelers. The ability to sort these potentially long lists on serial number, date of creation or stage of processing gave users a simple form of search. However, the system's main screen took the form of a table in which each column listed the travelers at a certain processing stage (figure 6). This followed directly from the format of the R & D team's weekly meetings. Each Monday morning the

department manager would build a spreadsheet on his laptop computer that showed all the wafers in fabrication, and project it on a screen in the meeting room. Each column of the spreadsheet listed all parts at a given stage of processing. These Monday meetings focused on filling in this spreadsheet, and discussing any problems that occurred in processing. During development of our system, the department manager abandoned this practice because it was too time consuming. Consequently, we decided that automating this display should be a priority for our design. It not only would support a point of view the team's leadership clearly valued, but also would provide an important bridge from the individual work of our users to the desired process unification.

The multiple hero narratives also called our attention to the differing needs of individual users. Early on, we thought of the LIGA manufacturing facility as a single unit. As we developed individual user stories, and the issues they considered important to developing the process, we came to understand the deeper diversity of people and technical skills LIGA processes required. We responded to this in the design by keeping it simple, and avoiding any features that were slanted toward a single point of view. Also, we made all data visible to all members of the team. This decision contrasts with more conventional traveler systems, which often restrict the visibility of information to only that demanded to perform a single step of the manufacturing process. We hoped this would foster unity of the fabrication processes, without forcing a single approach on the diverse user community.

Both the small size of our user community and the perspective of the hero's journey narrative helped us to find those individuals that would be particularly influential in the system's success. One critical user's work bridged several stages of the process: she was responsible both for the design of the masks used in X-ray exposure, and played a role in the development of the exposed wafers. She also had been with the team for a long time, and held a leadership role. Another key individual performed the X-ray exposure using the University of California's synchrotron. He was particularly important because his task was the first processing step: if he did not initiate a traveler, it would be unlikely to find its way into the system. This was complicated by the fact that his work required driving to the University to perform the x-ray exposure. The combination of distance, travel time and the lack of access to Sandia's internal network from UC, made his job particularly difficult, and created significant obstacles to data capture. Indeed, he was one of the first individuals to reject earlier automation efforts.

Once we targeted these individuals, we made a special effort to win their support. For example, we found a way to provide secure access to Sandia's internal network from an external computer at the UC synchrotron. Even though this caused our development schedule to slip by nearly three weeks, we felt the alternative of requiring data to be entered on paper forms at the synchrotron for later entry to the automated system was unworkable. It is important to note that this problem was not presented to us in our initial requirements. We did not discover its importance until a few weeks before scheduled delivery of the system. This problem was obscured by the earlier unity narratives, but was revealed as the hero's journey stories took precedence in our understanding.

An interesting function of these user narratives was to structure our relationship to the user community, and help us more quickly gain user support. We have already mentioned that our role in the hero's journey was that of the "donor," the individual who gives the hero the gift that makes the journey possible. This allowed us to achieve our goal of participating in the user community, while still maintaining the distance and objectivity our work as designers required. By providing a place for our involvement in these emerging narratives, it also helped overcome the distance between our location in New Mexico, and the LIGA team's work in California.

Thinking in terms of these two narrative threads does raise an interesting and still unanswered question. Users told us that they rejected the previous attempt to automate the traveler system because of usability problems, and our own evaluation of the system confirmed a number of usability defects, including slow response times and difficulties in navigation. But, although users responded favorably to our efforts to enhance usability, we are unclear if they did so because of the resulting interface's merits, or because our strong focus on usability suggested a commitment to their success and the quality of their work lives. We did not think of this latter explanation until we began analyzing our own relationship to them in terms of their individual journey narratives.

HOW THE DESIGN PROCESS REVEALED THE TENSIONS BETWEEN NARRATIVE THREADS

As our design work proceeded, it made explicit the different narrative viewpoints that had long existed in the user community. This took the form of an ongoing discussion of the goals and methods of deploying and using the Traveler System. These discussions reflected the tension between unity themes that defined our goals and the particular needs of individual users. They articulated the conflict between management's need to make processes uniform, and the tendency of engineers to have strong ownership of their work, and to be driven by immediate, specific technical issues. Although the multiple narratives we found did not cause these debates, they did give us a framework for thinking about them.

The multiple hero's journey stories did a much better job of revealing the complexities and pitfalls we faced in

designing this system than did the original unity viewpoint. For example, our original discussions of the system with both management and users did not bring out such problems as the need to access our network from UC. Here, we clearly benefited from the small size of our user community. We can only speculate as to whether attending so strongly to user stories would have been as effective in bringing these problems out for a larger user group, although both our experiences and our theoretical foundations suggest this would be the case. Careful sampling of the user community should provide similar benefits.

The design process revealed deeper tensions between these two points of view. For example, although LIGA technology was being developed at Sandia's site in Livermore, California, it was always intended that the technology would be transferred to DOE's Kansas City Plant as soon as it was ready. Our users, both of our immediate managers and we assumed that our system would serve the R & D community only. Once the processes had been perfected, it was everyone's intention that our travelers would be replaced by a process *control* system such as Factory Works. We were surprised, then, to learn that many people at DOE's Kansas City Plant and in upper management were concerned that our system might be inadequate to Kansas City's more formal manufacturing needs, or that we might try to force it on them. We also received criticism for designing a specialized system for R & D only, rather than having everyone use FactoryWorks or a similar MES system. This problem caught us by surprise, but can be explained by the dominance of unity narratives in people's thinking. We believe that the difficulty many people had in accepting either the value of a "niche" system, or our willingness to see our work abandoned as the LIGA process matured followed from the dominance of unity narratives in their understanding of IT.

Another area where our design effort revealed tensions between these narrative threads was in bringing out tensions between individuals in the LIGA community. These conflicts were generally defined in terms of technical specialties: researchers vs. engineers, people with manufacturing experience vs. younger engineers just out of university research labs. It also revealed conflicts between particular individuals (on which we will not elaborate for obvious reasons). Although we felt that revealing these conflicts was important and contributed to our success, dealing with them placed considerable burden on the design team. We could not simply focus on building software, but often found ourselves in the position of resolving tensions in the user community. Our responsibility in this seems inescapable: our own efforts at understanding the user community brought these tensions to the fore. Although we would have worked to clear up these problems anyway, recognizing the role our design process played in revealing these latent tensions made it clear that we were both responsible and uniquely qualified to resolve them.

CONCLUSION

Although narrative methods such as use-cases have proven their utility in software design, both theory and our own experience suggest that these must do more than state requirements in a narrative format. If they are to be effective, the narratives we rely upon in designing a system must engage the deeper patterns of meaning shared across the user community. They must help situate the design effort and the resulting system in these ongoing social processes. The stories users bring to their own understanding of practice and technology are powerful tools for accomplishing this.

In mapping user stories to either the unity or the hero's journey schemes, we are not trying to over simplify their messages to us. Rather, our own analysis looked for the deeper similarities that let us reason about the differing points of view in the user community. As we carried out our fieldwork, analysis and prototyping, this sense of common narrative schemes emerged. It was both a framework for our analysis and a result of it.

Deeply held, socially shared narratives can also be obstacles to understanding a user community. As Coyne points out [10], the unity narratives that tend to shape our thinking about IT can blind us to the deeper complexities a design effort must manage. We must separate the legitimate unifications of processes and information software can provide from the more fanciful ideas rooted in our culture's fascination with technology. Systematic field methods, cognitive analysis, and an understanding of the social context of practice and collaboration provide an antidote to these biases. As our experiences with the traveler system demonstrated, these techniques can help us exploit user stories as data, rather than accepting them as ground truth.

A problem that designers of collaborative systems must manage derives from the multiple, often conflicting, points of view that exist in the user and customer communities. Looking for the different narrative threads within a community gives us a framework for thinking about these often conflicting points of view, without getting mired in the particular disagreements underlying them.

Designers must recognize that their work makes user narratives explicit in ways that can bring the tensions between them to the surface. As designers, we must deal with the conflicts we induce. Recognizing that we are players in our user stories gives us a unique and fruitful take on participatory design. Understanding the diverse stories people use to think about their work can help the designer to enter the user community quickly and constructively. In our own work, our role as the donor of the hero's gift gave us a positive entry into the user community, and helped us achieve our goal of participating constructively in the

journeys of the people who began as our users, and finally became our partners and friends.

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