Cross-Cultural Scientific Collaboration Case Studies

Yu-Chung Chen, Ratko Jagodic, Andrew Johnson, Jason Leigh
Electronic Visualization Laboratory
University of Illinois at Chicago
851, S. Morgan, Chicago, IL
{julian, rjagodic, aej, spiff}@evl.uic.edu

ABSTRACT
This paper describes case studies and lessons learned from cross-cultural scientific collaborations. A computer scientist was embedded within domain settings to design and develop systems for geological core drilling and medical hand-off. While these domains seem diverge and have different purposes and workflows, one common theme emerged from reflection analysis. They all heavily depend on "observable artifacts" in early if not all iterations of design and development cycles. Utilizing the common and different signature characteristics would help identifying and taking the proper strategies for different phases of future scientific collaboration projects.

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HCI, Visualization, Software Engineering.

ACM Classification Keywords
H.5.3 [Information Interfaces and Presentation]: Group and Organization Interfaces - Computer-supported cooperative work, Synchronous interaction, Collaborative computing.

INTRODUCTION

It is hard to design a useful system. It is even harder to design a system for people who are in a different knowledge domain. In the software engineering world, researchers are seeking, categorizing and mapping [1, 2] the right software development model for scientific collaborations. Most of the efforts happened in domains which "computational" component has emerged close to one of the principal components of the domain, like high-energy physics, astronomy, computational fluid dynamics and bioinformatics. There are still more domains and phases in science workflows [3] where scientists work the way they did ten years ago with paper and pencil. Unlike the nature of computational science striving for optimization and robustness, these phases require more attention to support interactions between scientists and their tools to empower them to achieve their research goals.

Human-computer interaction studies proposed participatory design [4] and user-centric design [5] to include potential users in the design process. Cognitive scientists embedded themselves in real-world working environments to study "distributed cognition" [6]. Real-world users such as scientists may lack the motivation to have an outsider from other domains telling them what to do in their workflows.

On the other hand, researchers without prior domain knowledge might have difficulties understanding the context. Empathic design [7] was used in industry for commodity product design. Designers use activities such as biographies, scenarios, simulations, role-playing and social probes [8] to try to step into users' shoes.

While these practices are useful in designing commodity products, some of them may not be useful or even practical for scientific users, especially in the early stage of the design cycle. For example, the lack of background context might prevent the designer from fully understanding why a clastologist needs to count the number of rocks in a sediment core as soon as possible. The lack of mutual trust becomes another barrier during the design cycle.

The software developer should be embedded and immersed in the early stage of the development timeline. We believe this is more beneficial than merely joint meetings, conducting observation and dialogue activities from a third person perspective [9].

In following sections we will first describe each collaboration setting. Then we will discuss findings and lessons learned from these case studies.

COLLABORATION SETTINGS

Geological Core Drilling

"Geological cores are cylindrical bodies containing natural materials and sediments. Just like tree rings, the composition and deposition layers of cores contain detailed records of the climatological and ecological changes on the Earth dating back millions of years" [10].

To overcome the initial high domain knowledge barrier to know the working context of potential users, starting from summer 2004, one of the computer science students in the development team joined expeditions in ocean and lake drillings. The student received training as a junior core technician from an early stage of the design cycle. The work innovated the CoreWall system that is now used in LacCore, the Antarctica Drilling and International Ocean Drilling Program's JOIDES Resolution scientific drilling vessel [9].

Figure 1. (Above) Hundreds of hand-drawn notes lying across the office. (Below) Scientist switched to use the CoreWall system to assist initial core description.

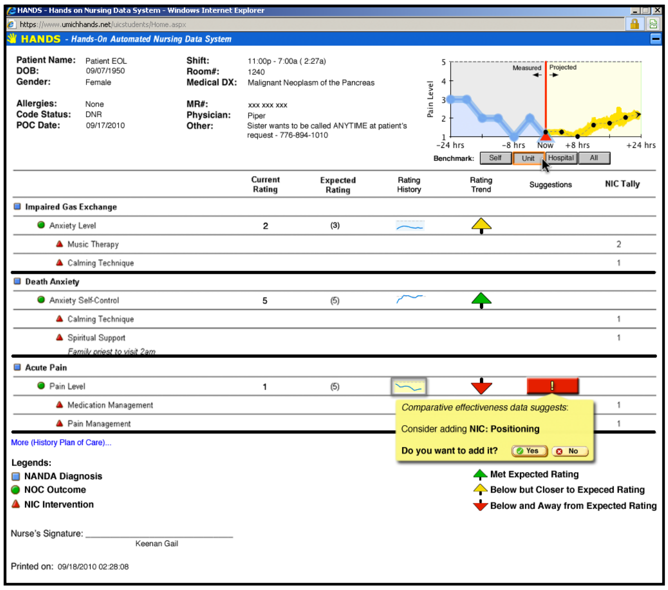

Figure 2. HANDS visual enhancements for decision support in shift changes.

Medical Hand-off System

The Hands-on Automated Nursing Data System (HANDS) is a standardized plan of care method in which the patient's plan is updated at every nurse hand-off allowing the interdisciplinary team to track the story about care and progress toward desired outcomes in a standardized format across time and units [11].

The on-going collaboration focuses on statistics, data mining and the visualization of the HANDS system. The visualization goals include: 1. Improving the original HANDS user interface for more potential users such as doctors and therapists. 2. Investigating and understanding the needs of prospective users, and adding additional functionality to HANDS to address the needs of those users. 3. Adding visualization to HANDS existing reports in an effort to empower current and future users to do more data exploration and visual analytics.

Transforming Classrooms with Wall Displays

The benefits of large high-resolution displays to the scientific community have been proven [13, 14] however, we believe these benefits can be extended to science education and classrooms in general. Enabling user interaction in such environments is still a challenge given their unique characteristics and affordances. We have therefore engaged in an immersive empathic design process with a computer science professor teaching a class on visualization and visual analytics. We put ourselves in the shoes of a student and attended the class for a year during which we applied different design and development approaches. The process began with an observational period, followed by participatory and iterative design.

The initial observational period pointed to several necessary features, which were then developed and deployed. Following the initial deployment, instead of simply acquiring feedback from the professor, we again assumed our student role that enabled us to make observations and provide feedback to the professor from the student's point of view. The feedback from the professor to the designer was crucial in assessing the usability of the implemented features. It also allowed us to gain a clearer understanding of what is acceptable and feasible in a classroom environment and not base design decisions simply on our assumptions.

On the other hand, given the novelty of the use of wall displays in classroom environments, there are no established workflows and therefore, the professor may not venture out of his traditional teaching practices, which may prevent him from fully exploiting the affordances of the new technology. In this case, putting the designer in student's shoes allows him to provide feedback to the professor and uncover further design features or changes that the professor may have overlooked.

These points clearly emphasize the need for immersing the designer into the environment thereby enabling close collaboration with the user. We continuously switched between assuming a student role, to collaboration with the professor and actual design and deployment. This continuous feedback loop and the perspective from both professor's and student's viewpoint, allowed us to gain a more complete understanding of the environment which resulted in more informed design decisions.

The success of our design process and the application of wall displays in classrooms have extended beyond the visualization class. Currently several other computer science professors, and even an art professor, have adopted this environment for their classes and are benefiting from this technology.

Figure 3. The high-resolution display wall used in the classroom environment.

FINDINGS

There are challenges designing and deploying an interactive system to real-world working environments. We found that due to various spatial and temporal constraints, the developer had to make use of different processes in design and development cycles. The "immersive empathic design" approach used at the early stage turned out to be the most beneficial in later reflections. It helped filling the gap of lacking mutual trust in early iterations. It was almost like a "ritual" of entering a new society. Passing the "ritual" created an invisible bond. The hands-on working experience was referred frequently during discussion in the workshops and conferences. Some evidences even showed changes in the scientists' workflows [9].

Differences

In the geological core drilling setting we found:

1. Users might unconsciously make assumptions based on prior legacy practices. The user interaction requirements and data affordances could be easily overlooked. The proposed approach sparks innovations within the workplace with emphasis on the value of users and the artifacts.

2. The information distribution pattern will affect how users use a system and interface design. The information flow pattern varies in different communities. The adaption of the annotation system during the Antarctica drilling expedition is one example where the designer and the developer should consider such implicit differences.

3. Scientists want the freedom to choose what tools to use. When a tool does not fit their needs, they will create workarounds by mixing tools in a way that is not anticipated.

In the on-going medical hand-off system collaboration, we tried to follow the same methodology and hoped the lessons learned could also benefit the new collaboration. Soon enough we found that there were fundamental differences in these two settings.

The nature properties of the artifacts produced in each workflow are different. Geological artifacts are highly hands-on and visual. For example almost all data routed into the CoreWall system has their real-world counterparts. High-resolution imagery came from the cores recovered from the drill site. They are tangible and after hands-on experience of one drilling workflow, it can be generalized and adapted to other drilling communities.

On the other hand, medical data during shifts is artificial and abstract. A lot of knowledge exists in the man-made definitions and professional conventions. For example, nursing diagnostics, outcomes and interventions were categorized into more than a thousand terminologies. A group of terms will typically be used to describe patients with a particular symptom. For now, the terminological combination knowledge existed only in the users' experience. As outsiders, we need constant explanations from domain experts almost more than 50% of the meeting time in the first 6 months. In the early stages, more close face-to-face meetings and trainings are needed to clarify ambiguity and misunderstandings.

Common Theme

One common theme emerged as we continued the collaboration in the second setting. It is that producing "observable artifacts" is crucial in both settings especially in early iterations.

In the first setting, the developer put together the first concept system right in the core lab during his hands-on internship. The system was setup right in the center of the core lab along with core description table. It was a "chop suey" mixed with monitors borrowed from other labs and slow rendering software. But it gave scientists a tangible artifact that encouraged discussion and brainstorming. An additional important lesson we learned was that prototype should be created in the form or media that it was supposed to be used, if possible. That might cost more time and effort, but it assures that down the road, scientists are having the user experience closest to the final system.

In the second setting, these artifacts became even more important. As discussed previously, the medical data is comparably more abstract. We found that producing a tangible representation of such abstract data was invaluable in the following ways. 1. If certain design does not make sense to a domain scientist, you have to make sure such designs fail early. And also such design prototypes have to be in the same form as mentioned in the previous section. The cost to revamp the whole design in later iterations would be more tremendous. 2. For domain scientists, it was a way to see if the developer understood the data. 3. For computer scientists that lack domain knowledge or experience, articulating these artifacts helps developing meaningful test cases to verify the correctness of the system. Both improved the mutual understanding of the domain science and also filled the gap between two different cultures while resolving misunderstandings.

CONCLUSION AND FUTURE WORK

This paper describes the case studies of system design and development of a geological core drilling system and an on going nursing hand-off system enhancements. The work in both settings involves the domain users, their work and interfacing artifacts. There were differences and individual tailoring processes might be required. But one common theme should be paid with additional attention. If the final system consists of components like visualization, user interfaces and the transformation from abstract to observable artifacts, more emphasis on the HCI than software engineering practices might be needed.

In the summer of 2010, the developer spent 2-months at an internship in a computer animation studio and found that it might be one potential setting for further investigation or borrowing experiences from [12]. Unlike computer scientist vs. domain scientist collaboration, the studio environment consists of computer scientists and artists. “Art challenges science, and science inspires art”, as Pixar Chief Creative Officer John Lasseter said. We could analyze and look into the successes of studios, see how similar the settings are comparing to the scientific collaboration, and whether the models and practices there can also be applied to scientific collaborations in future inquiries.

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