Crossing Boundaries: fostering interdisciplinary arts practice and human computer interaction research teams

Pamela Jennings
Human Computer Interaction Institute and the School of Art
Carnegie Mellon University
Pittsburgh, Pennsylvania
pamelaj@cs.cmu.edu

ABSTRACT
This paper examines the learner-centered methodology used to design technical and physical components for the *Constructed Narratives* project. Our approach demonstrates how an interdisciplinary team of designers, artists and technologist can exploit the opportunities inherent with "symmetry of ignorance" to solve complex wicked design problems and develop the gestalt generative design methodology. Team members completed a self-report questionnaire to assess the usefulness of the team management and work process for the project.

General Terms
Management, Documentation, Design, Experimentation.

Keywords
Tangible user interfaces, computer supported collaborative play (CSCP), design thinking, meta-design, symmetry of ignorance, shape grammars, extreme programming, gestalt generative design, architecture design theories, interactive art.

1. INTRODUCTION
The goal of the *Constructed Narratives* project is to develop a framework for the design of social interfaces, or "discourse wranglers," whose function it is to facilitate discourse, and support the intersubjective contextualization of ideas, assumptions and beliefs among its users. The social interface is a catalyst for the transformation and reinvention of the social and cultural environment. [1] *Constructed Narratives* is a block-based construction game that is based on the form and function of children's construction toys but designed for adults. The act and metaphor of construction is used to illustrate how a simple artifact can provide an interactive platform to support discourse between collaborating participants. Providing them with a convivial tool to articulate their problem solving activities.

Wicked problems are indeterminate and composed of multiple formulations of the initial design question and a bevy of plausible solutions. Wicked problems do not have stopping rules or definitive tests to validate the result. Wicked problems produce multiple justifiable explanations. The breadth of the explanation is dependent on the weltanschauung (intellectual perspective) of the designer. [9, 2]

Wicked problem solving is integrated into two stages of the *Constructed Narratives* project. First is the game experience design for end users. The second, an most relevant to this paper is the development of a system architecture that can support a modular system of physical artifacts. This second wicked problem presented our research team with multiple opportunities for system requirement negotiation, balanced by desired functionality and aesthetics of the artifacts.

2. PROJECT TEAM DEVELOPMENT
Assembling an interdisciplinary research team with each member as an equally valued stakeholder is a desired management goal of interaction design and human computer interaction research projects. This goal can only be attained when inclusive work methods are the norm and policy of the organizational structure. Solving complex design problems require a greater diversity of knowledge and technical skills than can be provided by a single individual. A method for solving wicked design problems encourages the integration of knowledge and practice from the arts and sciences. [2] The theory of "symmetry of ignorance," points out the inherent difficulties of organizing and managing a collaborative team with members from unique disciplines. [9] There is strength in diversity. That strength comes with the price of high hurdles to overcome. Individuals on a collaborative team bring to the project discipline-bound methods of practice that can lead to communication breakdown. The opportunities afforded by "symmetry of ignorance," can be cultivated to produce innovative products, only if the team operates in a learner focused, nurturing and respectful environment that is lead by a management system that can recognize the synergies between team members and institute productive work methods.

2.1 Team Selection Process
Carnegie Mellon University students with advanced technical skills can select from many high profile research projects to stretch their academic and intellectual curiosities. A major challenge to building the project team for *Constructed Narratives* was the recruitment of this same pool of students

to work on an interaction design and software architecture project situated in the School of Art.

The caliber of students applying to work on the *Constructed Narratives* project was very high. The final selection criteria were based upon their academic majors; prior work experience; participation in activities beyond their academic major, and a contagious enthusiasm to work on the project. The selected students were highly focused in their tasks, and yet flexible enough in their thinking to take on a project that was ripe with wicked problems, and complexity.

The final project team was comprised of undergraduate and graduate students representing the School of Design, School of Drama, School of Computer Science, Electrical and Computer Engineering, Masters in Information Management Systems, Human Computer Interaction Institute, and the Entertainment Technology Center. None of the students knew each other academically or socially prior to working on the project.

2.2 Team Meetings

Exploiting the opportunities inherent with an interdisciplinary research team requires a neutral meeting place where collaboration, creativity and taking risks can happen. The artist's studio in the School of Art served as this neutral safe space where social creativity flourished. Although the space was familiar to one team member, this was the first opportunity for most team members to spend a significant amount of time in the School of Art.

Giving the stakeholders of a design project decision-making responsibilities is empowering. This act of empowerment ensures the development of optimum design solutions given the scope and level of the team member's skills. The act of empowerment also promoted a self-efficacious "can do" attitude that transcended individual concerns over task difficulty or effort required to achieve a solution. The research team set out to design and develop a multi-layered system architecture for a tangible user interface network. The work process was divided into activities that evolved around five project components; project management, artifact design, user experience design, circuitry design and software programming. Keeping a project memory for team member transitions was crucial. Team members were required to submit a digital report. The reports enabled a cataloguing of potential technology and design solutions that could be examined for cost analysis and feasibility of implementation. The only guidelines for the digital report was that they had to be clear, concise and referenced. If these stipulations were not followed, then a revision was required. All reports were compiled into a project notebook that was duplicated for all team members.

Mandatory full team meetings were held at the end of each week. This meeting created a forum for each team member to report his recent research. The order of reports was alternated each week to give the topic of most importance ample time for discussion. Research topics included literature search on research projects with similar attributes to the *Constructed Narratives* project, architectural and design theories and practices that informed the design of the artifact, various hardware components and their feasibility for the project, and network interfacing protocols. Creating a software architecture that supported the connectivity of independent physical components was a rather complex problem to solve. The artifact, technology and software design all had profound impact on each other. The issues of aesthetics, experience design, communication protocols, and hardware solutions were the source of great discussion, debate, brainstorming, and whiteboard diagramming.

Smaller focus group meetings, held in the beginning of the week, provided a forum for development of specifications for components of the design. Focus group meetings were divided into two categories, software and hardware technology development and artifact and user experience design. Although it became necessary to create separate meetings for technology and design considerations, these core components of the project were not segregated or relegated a ranking of importance over each other. The segregation of design and technology development is very common in computer interface development projects. It is not unusual for the design team to be brought into a project after the specs of the software system are developed. Our technique of integrating all team members in full team meetings from the inception of the project, as well as having team members who are both designers and technologists helped to engender an appreciation for all design and development considerations. This technique, along with an implicit acceptance of the theory of "symmetry of ignorance," by all team members helped to support an efficacious design and development process.

2.3 Team Work Process

Figure 1: Extreme programming in action.

The ability and willingness to learn and teach in a collaborative knowledge-based environment is paramount for the successful design of a complex system. [7] Each team member brought a high level of diverse knowledge in their core research areas, yet they experienced large learning curves as a result of a couple of factors. The chosen technology solution was designed for developing very large component networks. Using the system required that team members learn enough about the basics of electronics to handle the programming, learn a technology-specific programming language, and learn the functioning of the systems multi-component software interface. The design of the block artifact presented many hard problems to solve, despite its simple visual form. The user experience design work required team members to grapple with understanding theories of semiotics and shape grammars.

Recognizing the high learning curve, elements of the Extreme Programming (XP) software development methodology were borrowed and molded to fit our work process. Extreme Programming is a gestalt approach to software design where the whole is much greater than the sum of the parts in terms of efficient software development process. Extreme Programming is a deliberate and disciplined approach to software development that stresses customer satisfaction, empowers developers to confidently respond to changing customer requirements and emphasizes team work where managers, customers and developers are all part of the team. Extreme Programming emphasizes four essential elements, communication, simplicity, feedback and courage. Programmers keep their design simple and clean. They get feedback by testing their software starting on day one and implement changes as suggested. An important technique of Extreme Programming is programming in teams. This process relies on the fact that better software design and problem solving can occur with greater diversity in the thought process. [4] The concept of Extreme Programming was extended to all aspects of the *Constructed Narratives* project from programming to artifact design. Standards, for writing code and artifact prototype development, were established in the beginning of the project. And methods for testing software and hardware designs were implemented that allowed a parallel design process where software, hardware and artifact design could proceed independent of any interdependence between system components. For example, after careful planning of the network communication protocol, a prototype circuit board was developed to facilitate hardware dependent software development. This enabled simultaneous development of software and hardware.

2.4 Team Self Report Assessment

A self-report assessment was administered following the first four months of the project. The short answer questionnaire was designed to assess each team member's feedback on the work process, their contributions to the project, and suggestions for work process improvements. Sample questions included: Did you find the team meeting process to be effective?; Did you participate in team programming and/or design sessions?; Did you find the preparation of reports beneficial to the process of understanding new technologies, processes, and concepts?; How would you rate your learning curve for the areas of the project that you were responsible for?; and What was challenging? Three out of four team members completed and returned the questionnaire. The fourth team member completed the questionnaire, but it was lost in the shuffle of graduating and leaving campus.

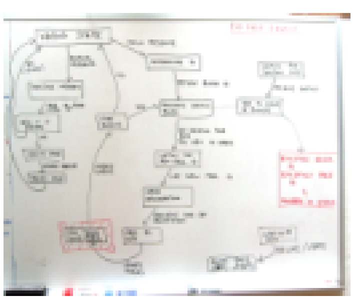

Figure 4: Software network protocol schematics developed during a brainstorming session.

Responses from all team members indicated that the report process was beneficial in helping them organize their ideas and keeping track of details that would have been lost in the brainstorming process. The reports also helped team members keep focus on their individual tasks while giving them an intermittent sense of accomplishment in the weekly oral summaries.

Figure 2: Team members grapple with understanding semiotics and shape grammars.

Figure 3: Brainstorming and diagramming during a full team meeting.

3. DESIGN PROCESS

"Complexity in design arises from the need to synthesize different perspectives of a problem, the management of large amounts of information relevant to a design task, and understanding the design decisions that have determined the long-term evolution of a designed artifact." [5]

Designers typically employ early conceptual ideas or primary generators to frame a design process. The primary generator is a seed from which the development of concepts and solutions are cultivated into a producible artifact. [3] The SER Model: Seeding, Evolutionary Growth, Reseeding process [6] is an alternative description of the horticultural metaphor for design process. The SER model emphasizes the transformation of complex design systems over time. The seed or primary generator is developed to allow modularity, extensions, and adjustments as the design process matures. The iterative nature of design lends itself not to the immediate design of final solutions, but to the creation of design spaces where the primary generator or seed can be mulled, sampled, and coaxed into a plausible design solution. The primary generator for the block artifact was based on the computational architecture design methodology of Shape Grammars developed by architect George Stiney. The primary generator for the Shape Grammar methodology was Froebel's kindergarten gifts. [10] The seed for the *Constructed Narratives* project is the block artifact.

Exploiting opportunities inherent in "symmetry of ignorance" requires the use of boundary objects [8] that serve as external explorations of ideas. These boundary objects are used to articulate tacit knowledge and ideas that may be too complex to describe verbally or linguistically. It provides a means for team members to interact, react and negotiate around a concept using concrete representations to create a common language for understanding and critique. [5] Each discipline represented in the project team contributed unique bounding objects to the design process. The computer programmers contributed whiteboard diagrams, schematics and application programming interfaces (API), the designers contributed sketching and prototyping artifacts using paper and other malleable materials, the artists brought an understanding of the narrative structures and semiotic systems.

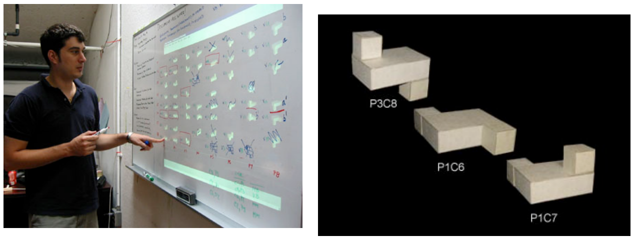

Figure 5: (left) Team process of examining the visual matrix for visual attributes of the shape grammars. (right) Final three shape grammars.

4. CONCLUSION

> *"We live in a world where problems often require the collaboration of stakeholders from different communities, each seeing the world from their own perspective, each having their own background knowledge and their cognitive, computational and physical tools and artifacts. Exploiting the symmetry of ignorance as a source of power requires not only a willingness to talk to collaborators, but also externalizations that allow people to think and to argue about and that help them to create incrementally a shared understanding of the design problem." [5]*

Multiple iterations of sketches, scaled drawings and physical models led to the design of the *Constructed Narratives* block. The fluidity of this process enabled us to draw upon the technique that could best answer the design or development question of the moment. Simple drawings and quick cardboard mockups were the most useful in aiding the brainstorming process. The development of scaled drawings with exact measurements and scaled physical models were important to the integration of hardware components. Functional and aesthetic design requirements were negotiated through iterative brainstorming and experimentation that supported a process of adding, substituting and removing design elements to invent an optimized solution.

The core components of the *Constructed Narratives* project were developed simultaneously. Maintaining a clear line of communication between team members was crucial for the prevention of misalignment with tightly coupled components of the system. Overall, the team honored the importance of the digital and oral reporting. As we pursued the design and development of the working prototype and software system, a few elements became out of sync with each other. For example, the size of the block body did not take into consideration the size of the final circuit board with all the connecting wires. The third component of the SER model, reseeding describes the process that occurs once a design has been tested. The current state of the system is synthesized and re-conceptualized based on the information and analysis gained through the development of the original idea. The result of the reseeding process is a new system that is used for future evolution of the concept.

5. REFERENCES

[1] Broeckman Andreas(2000) Public Spheres and Network Interfaces in Vectorial Elevation: Relational Architecture No. 4, edited by Rafael Lozano-Hemmer, Mexico City: Cultura y la Artes Mexico.

[2] Buchanan, R. (1995) Wicked Problems in Design Thinking. in: V. Morgolin & R. Buchanan, editors. The Idea of Design: a design issues reader. Cambridge, Massachusetts: MIT Press.

[3] Darke, J. (1978) The Primary Generator and Design Process, in proceeding of EDRA9.

[4] Extreme Programming, http://www.extremeprogramming.org/

[5] Fischer, G. (1999) Symmetry of Ignorance, Social Creativity and Meta-Design in the proceedings of Creativity and Cognition 99, ACM press.

[6] Fischer, G. Scharff E.(2000) Meta-Design: Design for Designers in the proceedings of DIS2000, ACM Press.

[7] Greenbaum, J. and M. Kyng, ed. (1999) Design at Work: Cooperative Design of Computer Systems. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

[8] Resnick, M., (1992) Beyond the Centralized Mindset: Explorations in Massively-Parallel Microworld, in Department of Computer Science, Cambridge, MA: Massachusetts Institute of Technology, pp. 176.

[9] Rittel, H. (1984) Second-Generation Design Methods. In Developments in Design Methodology, N. Cross (ed.) New York: John Wiley & Sons, pp. 317 –327.

[10] Stiny, G. (1980) Kindergarten Grammars: Designing with Froebel's Building Gifts, in Environment and Planning B, Vol. 7, pp. 409 – 462.