DESCRIBING THE INTERFACE DESIGN TEAM'S COLLABORATIVE DESIGN PROCESS USING PROTOCOL ANALYSIS

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Abstract

Consumers are growing accustomed to well designed user experiences. They impact users at all levels and experiences. To achieve a well-designed experience is to understand users and interaction design projects. They are complex and rely on multidisciplinary professionals perspectives to define the process and their resulting product. Interdisciplinary collaboration creates an environment that incorporates broader perspectives and experiences resulting in more user-centered design. Interaction design teams include but are not limited to interface designers, analysts, and developers. My research of interaction design teams is principally concerned with the group dynamics of those multidisciplinary collaborations.

In practice, however, the functions of gathering requirements, design and development are most often conducted as disparate, sequential activities rather than as a connected and cooperative effort. Requirements are incorporated into the project by designers, developers, and often project managers. Designers may hear about the client's objectives via the project manager. As a result, interpretation, style and experience can influence the information collected from the client. In these situations, communication across disciplines can be problematic. Developers may have difficulty understanding how designers are interpreting the findings of their research. At the same time, designers generally have difficulty articulating what part those findings play in the creative process. Further, designers do not always design with thought to whether or not what they have created can be developed.

The research conducted here evaluated interface design practice working within a design process that leads to productive collaboration between designers and developers.

The inquiry was an empirical study involving the observation and analysis of the activities of a small team working on an actual design problem in practice.

Function-Behavior Structure ontology, a protocol analysis scheme, was used to research two similar projects that used three face-to-face meetings to examine design sessions at different phases in the process. In this way, designers described their process and how they incorporated information about the project. The collaborative process was observed across developer and interface designer roles, to determine what part the process plays in the social construction of the design problem and in the design teams' formulation of creative solutions to the problem.

The findings from the two design projects indicate that the design teams' process is similar if not the same across project work. Also, their adherence to a process appear to be the same even though the final design products were unique and the solution to the problem ended up being different. The importance of clear requirements and purpose for the project to be understood at the beginning was proven in the difference in time spent on understanding the problem and arriving at the solution.

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Chapter 1

Introduction

It has been said that design is neither science nor art. Some researchers assert that design is a category by itself, which bridges the space between science and art. But many agree "designing for interaction is the human power to conceive, plan, and realize products that serve human beings, and, at its best makes life more pleasurable in the accomplishment of any individual or collective purpose" (Saffer, 2007, p. 6)—functionally, aesthetically, and socially. In fact, as technology becomes more prevalent in our lives, contemporary design could be one of the most important factors in humanizing that technology. To do this effectively and elegantly, designers need to understand a large number of human factors: physical, cognitive, social, cultural, and emotional. And, because different types of designers have different skills, training and experiences, collaboration among a team of multidisciplinary experts becomes essential. This requires designers to collaborate perhaps on a different level than they have before.

Yet, because the process may vary from designer to designer and place-to-place, the results from the designing activity analysis will guide when the designer should be part of the process and to what extent. For example:

1. A clearly established precedent for what role the interaction designer plays in the process doesn't exist;
2. A clearly documented or generalizable process that consistently incorporates interaction design at the same point hasn't been determined; but
3. A need to document the collaborative design process and to observe techniques,

strategies and tools that are used to provide insight into the process does exist. Therefore, this case study observed the collaborative design process by comparing two similar projects with similar objects to gain insight into user experience design.

The case studied for this research was carried out at University of St. Thomas, based on a team of interaction designers and developers, which practice interaction design for a variety of systems and applications. The practitioners were a multidisciplinary team of interface designers, developers and analysts. Summary definitions for interaction design, interface designer, software developer and development are in Appendix C.

Purpose and Significance of the Case Study

The purpose of this case study is to observe, record and analyze the interaction design process to gain understanding and improve efficiencies in user experience. The technology, skill and work in this area is constantly evolving and understanding the process is an important part of successful product delivery to clients.

1. To use observation and assessment to inform and improve the design process.
2. To look at how the design process is performed and analyze the effects it has on the outcome through usability of the project produced.
3. To evaluate if design is a uniformly followed process and assess if it should or should not be uniform.
4. To assess at what point it is critical for the designer to be involved in the process. For example, are designer's often involved too late?
5. To observe and document what issues arise because of reliance on technology to complete the collaborative design work.

Overview of the Methodology

Unlike previous studies reviewed, this study used a theoretical design perspective based on the following premises:

- Design is considered by some to be problem solving, and understanding the problem is an influential part of the design process (Cross & Cross, 1995);
- Design is social (Valkenburg and Dorst, 1998);
- Design problems co-evolve with their solutions (Schön, 1982, 1994); and
- Design is knowledge-driven (Rowe, 1987).

Researcher's conducting these studies attempted to describe design team activities and thought processes in action. Protocol analysis has been used in a number of design studies (Cross, 1986; Dorst, 2004; Gero, 2005; Gero and McNeill, 2006; Goldschmidt, 1992; Suwa, Gero, Purcell, 1998; Melican, 2000; Van der Lugt, 2003). Protocol analysis, a method, which analyzes data from verbal utterances, has emerged as the preferred approach. Function-Behavior-Structure (Gero, 1990) is one design prototype that has been used for different design disciplines and was the framework used in this research. This case analyzed and observed how and where collaboration occurs in the process, and assessed where and when the designer participated in the creation of the interaction design artifact.

Table 1
Outline of Research Objectives, Questions and Tasks

Research Objective	Research Questions	Tasks to Answer the Questions
Define the role the designer plays in the process. Identify the point of the process that incorporates design.	Can protocol analysis describe the cognitive and development process of designing? Is protocol analysis the most promising method for clarifying design-thinking behavior and providing the framework to describe the designer's role in web development and functional specification? What can verbal reports of thought sequences tell us about the role design plays in interface design projects? Should Web-based artifacts require multiple perspectives from designers and developers for the interactivity and functionality as part of the entire process?	Conduct (Function Behavior Structure framework described in Chapter 3) protocol analysis of the design process in three meetings across two projects.
Document the collaborative process and observe techniques, strategies and tools that are used to provide insight into the process.	Where is design in the production process? What collaboration techniques, strategies and tools are used in the design and development process?	Record, transcribe and code what takes place as part of the collaboration.
Evaluate if design is a uniformly followed process and assess if it should or shouldn't be. Assess at what point it is critical for the designers to be involved in the process. Are they often involved too early or too late?	Does the process vary from individual to individual? Does role on the project influence an outcome in the design process? Can the data gathered supply subsequent information to improve the design process?	Observe the process in the design meetings. Collect and code data to assess the design process.

Description of the Design Projects

This research project involved interaction between humans and systems. For this study, two web interface application design projects were selected to deliver complex information to users. Each application was innately multifaceted because it incorporated alternative and potentially conflicting perspectives and required integration and development from multiple enterprise systems. Therefore, these projects were ideal candidates for a group design project that benefitted from a multidisciplinary design team with interface design experience. Specifically, two projects under study were the design of an interactive timeline for the 125th Anniversary of the University (see Appendix B) and an interactive viewbook, for prospective undergraduate students, highlighting the undergraduate life experience at the university (see Appendix B). Both projects required user-interface design, information architecture, back end integration to existing systems and were complex in that they needed to be acceptable for a variety of audiences. They both require custom user interfaces.

Background

The World-Wide Web has become a major delivery platform for a variety of complex and sophisticated enterprise applications in several domains. In addition to their inherent multifaceted functionality, these web applications exhibit complex behavior and place some unique demands on their usability, performance, security and ability to grow and evolve. As an emerging discipline, web engineering actively promotes systematic, disciplined and quantifiable approaches towards successful development of high-quality, ubiquitously usable web-based systems and applications. Web developers practice Web engineering which focuses on the methodologies, techniques and tools that are the foundation of Web application development and which support their design, development, evolution, and evaluation. Web application development has certain characteristics that make it different from traditional software, information system, or computer application development.

Murugesan and Ginige (2005) describe web engineering as multidisciplinary and encompassing contributions from diverse areas: systems analysis and design, software engineering, hypermedia/hypertext engineering, requirements engineering, human-computer interaction, user interface, information engineering, information indexing and retrieval, testing, modeling and simulation, project management, and graphic design and presentation.

Web development is a broad term for any activities related to developing a web site for the World-Wide Web or an intranet. This can include e-commerce business development, web design, web content development, client-side/server-side coding, and web server configuration. However, among web professionals, web development usually refers only to the non-design aspects of building web sites, e.g. writing markup and coding with cascading style sheets or javascript. Web development can range from developing the simplest static single page of plain text to the most complex web-based interactive user experience applications, electronic businesses, or social network services.

Cooper and Reimann (2003) describe Interaction Design as the discipline of defining the behavior of products and systems with which a user can interact and the practice centers on complex high-technology systems such as software, mobile and electronic devices. Interaction Design is often associated with the design of system interfaces in a variety of media with a focus on developing the system to respond to the user's experience and not the other way around. The system interface can be thought of as the artifact that represents a purposefully designed interaction.

Interface designers practice the design of computers, machines, mobile communication devices, software applications, and websites with the focus on the user's experience and interaction (UX). Where traditional graphic designers seek to make the object or application physically attractive, the goal of interface designers is to make the user's interaction as intuitive as possible along with making the artifact physically attractive and is often called user-centered design.

Software is a general term used to describe a collection of computer programs, procedures, and documentation that perform some tasks on a computer system. The term includes application software that performs productivity tasks for users. The most complex software written at University of St. Thomas controls and coordinates distributed systems. The software acts as an interface or front end to tie into systems of record and bridge different systems for the user to create a more integrated experience interacting with the business operations of the university software systems for the end user. These systems include: the Enterprise Resource Planning system (ERP, a software system with integrated major business functions across an organization in this case, student records, financial aid, human resources, finance, accounts receivable, advancement and human resources management), the course management system, Blackboard, and Microsoft Exchange 2010 the system for email, tasks, calendars and resources. Examples of systems, University of St. Thomas builds, include: database repositories, communication applications, transaction systems and messaging-and-queuing software. Scheduled for development at the time of this study were an application that showcased the accomplishments and milestones of the quasquicentennial anniversary of the university and an undergraduate enrollment online application to showcase the life experience as a St. Thomas student.

Emerging initiatives in design practice require a strategic and operational examination of its process and production to develop an understanding of design practice and to challenge the concept of the design black box–that design is like magic or akin to divine inspiration. Understanding and acknowledging, instead, that design practice is a process that can be studied is critical.

Emerging strategic initiatives are raising awareness with product and service producers of all kinds of the importance of design itself, the importance of understanding it and of making design an integral part of any interaction design artifact project. This is true for a variety of industries faced with the need to distinguish, describe and educate the broader consumer not only to justify a competitive advantage but also to attract and retain talented professionals. Providing the most effective web and interactive interfaces gives that industry that differentiating advantage. As a result, to help focus and maximize resources, design professionals working in higher education and information technology attempt to predict learning methods, strategies and technology trends for coming years. Due to this growing awareness, the idea of what a university is and seeks to provide has broadened. In fact, for universities like the University of St. Thomas, space has become virtual as well as physical creating a demand for design skills. Learning itself, not just classroom learning, has begun to define the space where learning takes place. Virtual space has expanded from simply an online course in a course management system to a space that is blending and blurring the boundaries between learning about, and working and playing with, virtual worlds, simulation and gaming. Interaction design projects at St. Thomas range from creating a Virtual Tour interface to 3D maps with video navigation and on screen visually immersive environments. Learning how to create and to design in this space has become an important and competitive concern.

For over 20 years, computer based technology has enabled learning; however, the Web has allowed the online experience for university constituents to become even more important, more attainable and more compelling. An audience of customers/students, faculty, staff, community, and business partners recognize the importance of the virtual experience and are eager for content. Although this recognition gives enterprises the opportunity to provide education, universities need interaction design artifacts to improve product offerings. The rapidity of most enterprise organizational change requires ongoing learning and attainment of new skills and abilities and continuous improvement in process, understanding and collaboration.

Interaction Design

Current discussions of interaction design focus on the research aspects of design, the products produced and the method applied. These studies are often performed in a controlled student or research environment not practicing professionals. Much research in the field of interactive design comes from a cognitive psychological perspective. Although this perspective contributes an understanding of certain design aspects, this approach lacks a designer's perspective. As technology changes and understanding of interaction environments continues to evolve, these virtual environments will continue to be valuable areas for research. However, research into and observation of actual interaction design in practice that works for actual clients—not just in a simulation environment—is a valuable contribution to the field of design. Actual interaction design projects are complex design processes that insert the designer early in the process and evaluate function and aesthetics to create an innovative interaction for actual clients. This design and development area of interaction design is prime for research.

Understanding in-house expertise in interaction design in the high performance work place is a competitive advantage for universities. Empowering interface designers to cater to their audiences will have long lasting impact on the emerging student and workforce accustomed to high tech and high degree of personalization and universities must rely on a variety of metrics to inform their interactive design directions. For example, usability feedback from clients and participants determines the quality of the systems, which can only happen after that interaction takes place.

Interaction design artifacts, sketches and final products in the process

Design practitioners are beginning to evaluate interfaces and tools and to categorize them as viable study artifacts. These artifacts, including sketches and prototypes, inform their design decisions and provide a blue print for the development path taken. Enterprises are realizing the value in evaluating these decisions and aligning them with goals and performance measures. Technologies for measuring these goals are available in the marketplace and are providing data for analysis that is demonstrating the importance of user centered interaction design.

Increasing demand for interaction design in higher education necessitates research and study of several types of emerging Interaction design artifacts, as outlined in Table 2.

Table 2

Examples of Interaction Design Artifacts

Audio	Online Research Resources	Full Online Courses
Digital Images	Tutorials	Tutorial Services
Digitalized Text	Simulations	Instructional Modules
Linear Video	On-line Testing	Dynamic Learning Modules
Software tools	Animations	Intranets
Web Interfaces	Personalized Web sites	Interactive Video
Interactive Applications	Customized Web sites	Animations

Digital resources such as, marketing applications, content and materials that inform and communicate, and complementary support of traditional information and learning are becoming a competitive imperative. So that higher education institutions don't fall behind their competition, they must spend resources on building and designing these types of artifacts. In reality, institutions can choose from two paths: 1) Business as usual (the "reactive" approach), which is incrementally responding as problems grow, and using today's systems and processes to handle tomorrow's problems; or 2) Anticipate and collaborate (the "proactive" approach), anticipating tomorrow's realities today, and meeting common needs through shared resources. The proactive approach provides a number of economies of scale.

If in-house designers do not yet have these collaborative and technical skills, institutions will have to create a means for acquiring them and give designers a venue for practice. Practice is important to the success of the artifact because the interactive approach lets the users of the system question the material and create their own models and strategies, thus, make meaning through interactive experiences. The content communicated to the users is a consequence of that interaction, and the actual manipulative activity they engage in makes the content more comprehensible.

Unfortunately, institutions with in-house designers aren't always involving the designers early enough in the process. Institutions need a better practice for when the designer should be involved. Although some of today's human-computer interfaces, of which interaction design is considered a category, incorporate an understanding of web and mobile delivery. The institutional priority and monetary investments must include early and ongoing designer involvement in addition to buying the technology infrastructure and moving the content, interaction or process to the virtual space.

As skills and projects have matured and tools and goals have increased in complexity, interaction design has become a more visible profession, and consequently interactive design professionals are beginning to articulate their work more precisely. For example, Reimann (2001) defines interaction design as a design discipline dedicated to defining the behavior of artifacts, environments, and systems therefore, interaction design is concerned with deriving from products as it relates to their behavior and use. Anticipating how product use will mediate human relationships and affect human understanding. Exploring the dialogue between products, people, and contexts (physical, cultural, historical). In a presentation to AIGA, Forlizzi and Reimann (2001) described interaction design as providing a design perspective that approaches product design from an understanding of how and why people desire to use the product; as an advocate for the users and their goals; as gestalts, not simply as sets of features and attributes; and as a view of the future—seeing things as they might be, not necessarily as they currently are.

Effective interaction design teams have commonly understood characteristics which include the ability to learn new domains quickly; to solve problems both analytically and creatively; to visualize and simplify complex systems; to empathize with users, their needs, and their aspirations; to understand the strengths and limitations of both humans and technology; and, to share a passion for making the world a better place through ethical, purposeful, pragmatic, and elegant design solutions. Owen (2004) said "design [in general] involves problem finding, problem solving, analysis, invention and evaluation guided by a deep sensitivity to environmental concerns and human-centered aesthetic, cultural and functional needs" (p. 3). While considering what types of skills interactive design teams need in order to work in complex environments, describing the characteristics of their processes to ensure they have the appropriate skills to get the job done is equally important. Appendix C provides further description of the interaction design team including developers and analysts.

Design Process

Changes in delivery methods of interaction designs has resulted in a higher education resurgence in building multimedia and interaction design because of software design projects that now live on the web or can be part of the course and content management system repositories. In order to prepare some resource materials for these repositories interactive design teams must have expertise in as many as seven or eight different areas, such as: technology, education, analysis, project management, instructional design and the subject itself. Clients and circumstances require designers to develop both task and content expertise;

to understand principles for effective multimedia and interaction design; to have the problem solving skills for developing their projects into content element modules for specified audiences; and to have the cognitive strategies for developing approaches to designing such modules. They also need to possess positive attitudes toward collaboration and toward incorporation of principles of effective content authoring. Depending on the project strategy, complexity, and desired outcome, there are a number of possible scenarios for when the design role enters the process and who is needed to help perform this role. Some projects require less design and/or technical skills; however, more often than not, projects require a team with both designers and developers participating.

As such, the emphasis of this research was on the client and analyst collaboration, which is where the requirements originate. Rather, this research focused on the cross-discipline team that collaborated and combined knowledge to provide the support, development, design, and production of these elements. The overarching framework for the structure of interaction-designed systems is the design process, which provides the support for designers to build the experience for their intended audience.

Multiple researchers (D'Astous, Derienne, Visser, Robillard, 2004; Lahti, Seitamaa-Hakkarainen, Hakkarainen, 2004; Poggenpohl, 2002; Woodhouse and Patton, 2004) describe the design process as complex. Because factors from learning styles to technical limitations may impede its development, it is essential to provide a supportive work environment. Furthermore, understanding and supporting the design process is an important institutional investment and a testament to the quality and satisfaction of constituents with the product deliverables and a competitive advantage in general.

The Design Process Is Problem Solving; Where Is the Designer in the Process?

The complexity of the design process makes it critical to evaluate where and when the designer should be involved. In much of the design research to date, the term proximate designer is used to describe design professionals and practitioners who exercise direct control over the details of design. However, proximate designers work under constraints and incentives established via complex social arrangements involving persons often far removed from the drawing board. For example, the proximate designer might get requirements from a project manager or an account manager who is removed from directly interacting with the client. Neither of these professionals has direct design experience and may potentially miss critical information that the designer needs.

Technology Influences the Designer's Process and Co-Evolves with Artifacts Produced

Because no established framework for the interactive design process exists, individuals, organizations, and societies often behave as if they are going through the motions, allowing innovations to take paths not deliberately chosen (Woodhouse and Patton, 2004). Because interaction design professionals view technology as separate channels of functionality, designers fail to look at the long-term implications of using a tool or object on their work. As a result, little attention has been given to researching the effects of proximate designers adopting technology such as drag and drop, auto form insertion as evolving functions that become accepted best practices and their influences on design. Designers must often fit their design into the expected behavior of the system or take into account functionality of the system before the structure can be aesthetically incorporated. Woodhouse and Patton suggest that in our everyday design practices, designers take much of the world as it is, assuming the lasted technology function is the best option and we should adopt it for practice without question, an assumption that shapes design decisions and influences decisions made about the presentation of the designed product. Technology studies exist and range from simple artifact creating to developing complex socio-technical systems, but research has not focused on use of technology innovations or artifacts created during the process to measure the impact on the process framework. Interactive designers draw from other designs and often use a case-based design approach by leveraging already well tested and established functionality but approaching it in new and different ways. Woodhouse and Patton (2004) said “people and technologies are combined to work as heterogeneous but functional wholes” (p. 5).

Three areas of concern result from this lack of a process framework: 1) a tendency for technological innovation to proceed without sufficient contestation and deliberation; 2) great inequalities in who benefits from designers’ energies and skills; and 3) nontrivial side effects, synergisms, and second-order effects that no one is responsible for foreseeing and pre-empting (Woodhouse and Patton, 2004). Although, the technologies used and deployed are important factors in the final product, critical to this discussion is that they are also an important part of the process in productivity, display of the medium during the process and key steps in the collaborative process.

Design is Social and Multi-disciplined

Woodhouse and Patton (2004) described the complex and often unclear process of design as follows: 1) no simple boundary adequately delineates what counts as design or who engages in it; 2) design reproduces – often unintentionally – social norms, values, and assumptions in the products of design; and 3) under these circumstances, designers are not entirely free to choose how a product, building or artifact will be shaped; therefore, other forces wield considerable influence on their ability to leverage technological innovation. The complexities of artifacts that are designed to meet today's requirements involve a multi-disciplined, interactive, collaborative approach to creating them. This approach requires skills and perspectives inherent in software engineering and interaction design to achieve the possibilities of the predetermined goal.

As established through this discussion, the preparation and construction of interaction design artifacts are no longer the work of one individual, but the work of teams of specialists—interface designers, information architects, system architects, developers, media specialists, subject matter specialists, instructional design specialists and learning specialists. Furthermore, McLoughlin (2002) supports that a great deal of research indicates that consumers need to be given more control over their interactive environment and the activities they undertake. Nevertheless, in some cases, information and content is being ported without rethinking the message design of the traditional content before placing it in online environments, thereby underestimating audience need and expectations. Designing for interaction involves reengineering the materials and the goals, re-conceptualizing roles for audience interaction, emphasizing not just participation, but also fostering task engagement, social and peer feedback. Ultimately, the goal of the design process is to create a sustainable system that anticipates navigation, interaction and support that ensure consumers' engagement in the process, and that achieves expected results.

Design teams, whether they are cognizant of structure or not, do their work following a number of different models with structured methodology. Work process typically starts with some type of planning or analysis validated against the client's expectations. The designer then begins working in the design phase. Historically, the disciplines of architecture, engineering and product design have developed different models to follow during this design phase, which are described in Chapter Two.

Collaboration

Collaboration is integral to any creative endeavor involving groups of people in diverse fields, from product design, to urban architecture, to interaction and web software development. If the relationships and coordination between people, designers and developers are poor, no amount of design brilliance or methodological craftsmanship will save a project. Rather the partnership of synthesis (design) and analysis (usability) makes great user experiences happen. However, Cross and Cross (1995) posit that working as a member of a team in comparison with working alone introduces different problems and possibilities for the designer and selected seven aspects of designing to observe to manage the problems and possibilities: roles and relationships; planning and acting; information gathering and sharing; problem analyzing and understanding; concept generating and adopting; and conflict avoiding and resolving. Cross and Cross concluded that design methodology must now also address the design process as an integration of technical, cognitive and social process.

Design Collaboration and Technically Reliant Workspaces

Collaborative technology is a necessary part of both design and development. Perry and Sanderson (1998) assert that an increasing number of technology developers are orienting their work effort towards supporting the group work of designers and developers. Recently, design researchers Kan and Gero (2009) began studying collaboration technology, and collaboration in the design process. They considered collaboration in product engineering and architecture for study in practice, but have not yet applied their ontology to interactive and user experience design. This deficit can be attributed to the complexity of measuring collaboration and emphasis on tools analysis in practice. However, because collaboration is a vital part of the design and development process, it also requires analysis and evaluation.

For successful large and complex projects, teams need diverse abilities, and because no one person has all skills necessary to produce large products, software or digital production requires a multidisciplinary team approach. When multiple people are involved, decision-making and workflow management becomes vital, and, therefore collaboration technology becomes critical in any creative pursuit involving groups of people.

Haymaker, Keel, Ackermann and Porter (2000) indicate that issues traditional collaborative design faces in a world of increasing specialization and delegation include:

- Communication—spatial and temporal constraints of verbal communication that inhibit the transfer of knowledge.
- Representation and meaning—different disciplines evolve different representations and languages for their domains.
- Memory and information processing-individuals and collaborators struggle with large, combinatorial tasks.

- Coordination—distribution of intelligence generates extensive difficulties in the task of coordination.

Furthermore, collaboration between developers and designers impose different constraints. A constraint to a designer may not be a constraint to the developer. For example, the design may have included a pull-down menu that used graphics, but the developer coded a solution that used text for page load speed and ease of implementation. Their different perspectives shape the outcome and sometimes change intended functionality for a solution that takes in a broader understanding of the problem. Designers move simultaneously in and between composition and construction spaces controlled by the characteristics of the design constraints and design context. Design constraints form the design context by defining, for example, the intended users and their special needs for the artifact and its function. Designers and developers interpret functional requirements from the user from different perspectives, which result in different approaches that need to be discussed and negotiated. Lahti, Seitamaa-Hakkarainen, Hakkarainen (2004) describe working with design objects as consisting of two problem spaces, i.e. composition space (visual designing) and construction space (technical designing).

Authors Kirschner, Strijbos, Kreijns and Beers (1997) provide an additional note encouraging developers to think beyond designing for control over the environment by asking questions related to content development. For example, design all too frequently begins with questioning the intent of the message the client wants to convey, rather than, the purpose consumers of the message. The concept of design itself is indicative of a user-centered approach; it consists of user centered design, user-centered interaction, and user-centered delivery. Kirschner, et al. (1997) conclude that designing more interactive and user-controlled content will build more democratic discourse and community oriented discussion. Consequently, the inclusion of interactive components is a necessity, and current network technology provides a myriad of options to incorporate constituent interaction into the interaction design. Further incorporation is needed and the effect of these various tools on process, goal achievement or knowledge transformation needs more analysis.

Design Research from Design Practitioners, as it is Knowledge Driven

The research reviewed on interaction design has not looked at design from a design practitioner's perspective. This study brought that perspective to the academic conversation. In fact, Poggenpohl (2002) supported the call to action for practicing designers to look at how research is being informed with a design practitioner's perspective especially in the fields that are influenced by interactive technology. She described three categories of converging factors that support research from a design perspective: technological influences, contextual change and education opportunity.

At the same time, intense competition for human attention is created by the overabundance of information resulting from contextual change. Understanding what is design literacy and how designers incorporate and extend their work is a factor in assessing knowledge-building in design. To address this attention deficit, the information knowledge discipline is under pressure to apply design principles to solve interdisciplinary problems through the creation of knowledge bases and repositories for the process. Simultaneously, individuals engaging in information construction are challenged by what is established research and what is yet to be researched in the context of their design problem. According to

Poggenpohl (2002), changes in technology, communication, and the education and design context create ripe opportunities to evaluate design practice in higher education.

In addition to these factors prompting opportunities for design research, Poggenpohl (2004) described an emerging trend that seeks external views for solutions to persistent problems that will bridge inter-disciplinary perspectives and contribute new knowledge. Thus, the convergence of technical, contextual and educational factors, along with a call for design perspective-focused research, establish a need for evaluating collaborative design practice in using communication and interactive technology. The basis of the master-apprentice model is common learning strategy in design practice. Poggenpohl suggests the opportunities are that tacit skills remain important; the context of design becomes more differentiated in that the ideas can be made abstract and explicit so both working together enhances the designer’s performance.

Scope and Limitations

This case study analyzes collaboration in the interactive design process by measuring the variables and frequency discussed as design and development producers practice them. This research demonstrates a generic coding schemes utility for studying collaboration in design, a framework for discussing the design language, and for describing the collaboration processes used in actual interactive design projects.

Although, there have been a number of studies performed on students in industrial and product design (Cross, 1997; Goldschmidt, 1992; Lauche, 2005; Perry and Sanderson, 1998; Valkenburg and Dorst; 1998), they have been conducted predominantly in the studio (Denton, 1997; Lahti et al. 2004; Valkenburg and Dorst; 1998). They were not conducted as actual design practices and not specifically in interaction design. By looking systematically at collaboration in the actual design process and with regard to how designers and developers contribute to building artifacts, the results from this study were two case studies compared because of their similarity in goal and team effort. This study, then, examined the process of designing two practice situations in which the meaning of collaborative interactive design can be described and analyzed. The results analyze the data, discuss the outcomes and identify further developments. The analysis culminates in recommendations and some examples of when and how the collaboration process can be described and demonstrated in interactive design to improve the design process and ultimately the design deliverables.

Summary

This study provided a unique opportunity to explore a design team in practice collaboratively developing two design projects for the University of St. Thomas. Chapter 2 examines the literature in this area; Chapter 3 describes the analysis and observation methods of this collaborative design experiment; results of the study are discussed in Chapter 4, and study conclusions in Chapter 5.

Definitions

Interaction Design
Löwgren, (2002) Most people in the field of interaction design would probably subscribe to a general orientation towards shaping software, websites, video games and other digital artifacts, with particular attention to the qualities of the experiences they provide to users. The word "interaction" in interaction design captures the time-based, and at the same time, nonlinear nature of the digital, a quality that sets it apart from most if not all other design materials.

Design Practice
Practice is used to distinguish between research conducted as simulation or scenario versus research that is conducted in circumstances where the work is an actual product that is created for clients requesting it and will be put into live use and production.

Proximate Designers
Woodhouse and Patton (2004) Proximate designers, including product, industrial, graphics, and urban designers and architects are those who exercise direct control over the details of design. Proximate designers work under constraints and incentives established via complex social arrangements involving persons often far removed from the drawing board (p. 1).

High-Performance Workplace
Gartner (2006) A high-performance workplace combines technologies, processes and management so workers can create more value. This area integrates multiple technology perspectives, including collaboration, information access, content and knowledge management, messaging, portals, e-learning and productivity tools.

Multidisciplinary team
A multidisciplinary team is a group of people with a mix of skills who are organized to work together towards an objective that they share.

Distributed Designer
Distributed designers are designers that don't all work in the same area or location. They may work for the same company or they may not, but for some reason there is a call for them to work together and collaborate on an objective they share.

User eXperience (UX)
The creation of the architecture and interaction models that affect user experience of a device or system. The scope of the field is directed at affecting all aspects of the user's interaction with the product: how it is perceived, learned, and used.

Software Engineering
It is a profession dedicated to designing, implementing, and modifying software so that it is of high quality, reusable, maintainable, and fast to build. In the case of University of St. Thomas, it is an object-oriented systematic approach to the analysis, design, assessment, implementation, test, maintenance and creation of software.

Software
It is collection of programs and related data that executes instructions for a system on what to do and how to do it. Software refers to one or more programs and data held in the storage of the system for some purposes. Software is a set of programs, procedures, algorithms and its documentation concerned with the operation of a data processing system.

Collaboration
It is an iterative process where two or more people or organizations work together to realize shared goals. For example, a project that is creative in nature—typically a collective, determination to reach an identical objective by sharing knowledge, learning and building consensus to achieve the result.

Design Prototype
It is a conceptual schema for representing a class of a generalized grouping of elements, derived from like design cases, which provides the basis for the commencement and continuation of a design. Design prototypes do this by bringing together in one schema all the requisite knowledge appropriate to that design situation.

Design Activity
A goal-oriented, constrained, decision-making, exploration and learning activity which operates within a context which depends on the designer's perception of the context.

Chapter 2

Literature Review

Historically, design disciplines looked to strong research traditions in psychology and sociology for answers on design. Although not directly related to design practice, these disciplines contributed a body of knowledge that assisted in describing design and collaborative design. Forlizzi and Battarbee (2004) asserted that designers offer a unique perspective for the kinds of user-product interactions, experiences and changes over time. A system is designed and evolves as users adopt and interact with the system and other emerging systems around them. However, the designer's unique understanding of products and context, coupled with approaches to obtain a detailed knowledge of users is but one of several perspectives within a multidisciplinary team—defined in the case of this study as, a team with one or more design roles, one or more developer roles and an analyst or project manager. Forlizzi and Battarbee (2004) also asserted that although integrating all these perspectives is a challenge, [the integration] has resulted in a growing popularity of ethnographic research methods being applied to design practice for exploring the form, function and the content of the interactive products.

This literature review examines the existing body of research that describes the contribution designers' make to the development process and/or that analyze the procedural steps of constructing an interactive design product. The strategy used to inform this research is described in Search Strategy. Design Theory Research examines design theory research and briefly describes approaches to design process methodologies. In Interaction Design, designers, their analysis, evaluation and knowledge is discussed. In Collaboration Design, the collaborative design teams' design process is described.

Search Strategy

The review of literature included an examination of research and studies in design, human computer interaction design, design process and collaborative design. However, the review was not exhaustive in these fields because the scope was limited to contributions that directly related to design, design process and collaborative design. Areas that surfaced in relation to the search for collaborative design were computer mediated communication, collaborative design and development in engineering and software, and collaborative design in industrial, product, and architecture. Much design research on collaboration has been in the areas of engineering and architectural design. More recent research has widened the range of potential technologies to study, and includes broader applications for capturing and analyzing interaction design. Further, studies have typically been studio or student based not practitioner oriented (with the exception of Button, 2000; Detienne, Martin and Lavigne, 2005; Stumpf and McDonnel, 2002). Some design workshops and participating designers have participated in research that, during the session, created artifacts and contributed towards an initial body of research in practice design observation and analysis. However, there still exists a need for a more detailed knowledge of design and the designer's process to generalize design work and understand it from a design perspective. The most relevant technical disciplines that aid interactive designers are visual and industrial designers working with interactive designers to create complete product designs (Gero, 2005; Gero and Kan, 2009; Gero and McNeill, 2006). According to Lahti, et al. (2004), human computer interaction research is emerging as a substantial contributing body of work in web design and evaluation because some researchers consider interaction design as a category of human computer interaction and others consider it with user experience. Some of these studies are also discussed, (Gilbert and Driscoll, 2002; Lahti, et al., 2004; Poggenpohl, 2004) as they related to forming a body of research in collaborative design.

Design Theory Research

Design is frequently thought of as an art rather than a science. In addition, many designers were often self-taught innovators who possessed skills to approach design from an intuitive, comparative, or practiced perspective rather than an education model. As a result, "Education and practice in design have long been estranged, due in no small part to its craft basis and the self-taught nature of many of the now retiring or just retired design professionals" (Poggenpohl, 2003, p. 143). However, design programs at universities since the 1950s have grown, resulting in designers who have at least a bachelor degree (Poggenpohl, 2003). Industry now requires educational programs to prepare designers to understand not only design principles, but also to arrive on the job with skills in technology and tools of their trade. In addition, Poggenpohl (2003) asserted, some "more progressive practitioners value student experience with teamwork, multidisciplinary projects, user studies, even speculative thinking about not ready for primetime technology" (p. 144). And, although the void between practice and education is diminishing, there remains a disconnect between practice and education when design practitioners, design experts and design researchers do not contribute to knowledge and experience in best practices.

Difficult to Do Design Research in General

Bayazit (2004), in an article of a forty-year review of investigating design research, concluded that design research is about obligations of design to the humanities. He listed five areas with which design research was concerned: 1) how man-made things work and perform their function; 2) how designers work, how they think, and how they carry out design activity; 3) how an artificial thing appears, and what it means at the end of a purposeful design activity; 4) how relationships and patterns in design are represented; and 5) how acquisition of knowledge is related to design and design activity. This case study focused on how designers work and create artificial things through a purposeful design activity.

Poggenpohl (2004) urged the design researchers to study the following aspects of design production: the interactive and development process, and collaboration and technology. These areas should be concerns internal to design because they aid design. Although suggested, demand for researching design practice external to design is gaining emphasis because of increased accessibility and adoption of technology, there still exists the need for researchers from design to analyze design and technology from a design perspective. Process, technology and development are practiced and can be measurable from a performance standpoint.

For these and a variety of other reasons, design practice has been difficult to observe and analyze. This difficulty does not just result from the complexity of the tasks, the difficulty measuring collaboration, or professionals not being required to perform research as part of their practice. But, as described by Sebastian (2005), what adds to the difficulty in identifying and measuring communication and design goals is that most design problems are ill-defined, interconnecting many factors, and always including solutions that incorporate varying perspectives arrived at by dynamic tension and creative and problem solving. These all have contributed to the deficit of interactive design research to date. In addition, the design process is iterative and the analysis is usually done as a process of synthesis requiring skills possessed by design practitioners and their unique competence for “simultaneously reconstructing the problems and reframing the solutions” (Sebastian, 2005, p. 81).

Borrowing from Other Disciplines

According to Poggenpohl (2002), design has been able to look to disciplines with strong research traditions such as psychology and sociology to provide a substantive and methodological transfer of knowledge; however, the questions and manner in which these disciplines approach the research question “are often difficult to interpret in terms of design action” (p. 248). The most common conception of design problems is to consider them all “ill-structured” problems (Detienne et al., 2005). Therefore, design isn’t a black box or magic worked behind the scenes. Rather, design is a process with systems and models that are applied and is an iterative, collaborative evolution with multiple viewpoints and perspectives that contribute to the final solution.

Design research has responded to its challenges through a variety of methods, often borrowed from other fields. However, Storkerson (2003) asserted that design practice has concerns about design's relations to other sources of knowledge, its own claims to knowledge and its ways of thinking compared to the sciences, humanities and arts, especially as it borrows from fields that relate to design but are not entirely compatible with design. Thus, although design has been able to draw on other disciplines and has benefited from some initial research in design and approaches to studying design, a critical body of research and knowledge is needed to round out the design discipline. The results of my research inform interaction design, designers and the surrounding discourse in the design community.

Protocol Analysis

The use of verbal data to study cognitive processes and protocol analysis is common in many areas of psychology, education, cognitive science and design. Researchers driven by the difficulty of relying on external observation in studying cognitive processes argued that individuals privileged access to their experiences was valid. To avoid the problem of asking subjects to recall the account of performing the task after the fact and capturing the actual cognitive process concurrent verbal reports were collected as think aloud protocol.

Protocol analysis has been used to compare a number of cases involving different groups and individuals in the design profession. Several studies have been conducted on dynamic or virtual worlds and the face-to-face environments (Gero, J and Kannengiesser, 2006; Kan J. and Gero, J., 2009; Kan, J. and Gero, J., 2006; Kan, J. and Gero, J., 2005). Kan, Bilda and Gero (2007) compared six architects in twelve design sessions with two different experimental conditions. Stempfe and Schaub (2002) observed three laboratory teams over six hours to categorize the design process. Two protocol studies of electronic engineers were conducted and presented in Gero and McNeil (1998). In a separate study conducted with the electronic engineers McNeil, Gero and Warren (1998) used the Delphi Method to code the electronic engineers processes and test the coding method.

A formal representation of the processes of designing research using protocol analysis is Gero’s (1990) function-behavior structure framework. Since publication it has been applied to several studies (Gero, J and Kan, 2009; Gero, J. and Mc Neill, T., 2006; Gero, J and Kannengiesser, U, 2004; Goel, V. and Pirolli, P., 1992). A conceptual schema representing a grouping of elements from like-design cases, a design prototype separates function (F), structure (S), expected behavior (Be) and actual behavior (Bs). Although individual designers develop the contents of a design prototype, Gero asserts designers having similar ideas and experiences will tend to agree on its general contents. For that reason this framework has been used in a variety of design studies for different design disciplines such as architecture, product design, manufacturing, mechanical engineering and software engineering. Chapter 3 describes the F-B-S framework and this study's application of it to interaction design.

The Design Process Is

Although the design process is describe as complex (Woodhouse and Patton, 2004) like-minded designers posses and add to design prototypes during the course of developing designs. The designer's job is to work directly and indirectly with clients, but the overall process of design is far more complex than what is suggested by the straightforward relationship between designer and client. In fact, designers are faced with a variety of important conceptual considerations. Some elementary components of interface designers' practice include concepts of user and system behaviors.

Technology and Collaboration Are Changing the Design Practice Landscape

Bayazit (2004) the 1960s marked a shift in designers' practice because "…designers could no longer rely on the product as the center of a design task" (p. 17). Technology advancements and resultant mass production implications shifted the focus from equipment, technology and form to a focus on a reflection of human needs that resulted in design methods as the new subject for analysis.

Groupware systems designers are increasingly creating systems with a view to supporting the work of design and engineering groups (Perry and Sanderson, 1998). Groupware described by Hayne, Smith and Turk (2003) as "…software supporting group interactions, of which there are different types… They categorize groupware by size, frequency of occurrence, composition, motivation and decision process, technology, dispersion and synchronicity" (p. 524). Initial research efforts included research and observation with the use of multimedia technologies such as Netmeeting and 3-D virtual simulation tools to support groups of distributed designers. Fashion design, architecture, and engineering are using technologies as solutions to help them work together to overcome what are perceived to be problem areas for designers. Perry and Sanderson (1998) concluded that group-based design and engineering is yet another form of work that would benefit from the increased use of computer and communication technologies. Hayne, Smith and Turk (2003) suggest that "a complete groupware infrastructure has four dimensions: communication (pushing or pulling information), collaboration (shared information leading to shared understanding), coordination and control (management of conflict). Each of these dimensions can assist design problem solving in problem areas" (p. 524).

Design research has moved beyond a reductive argument debating which ways are better and that some are better than others. Emerging research is instead positing the question of the emphasis that is placed on different aspects of design development and process through collaboration.

Design Process Methodologies

Uniting aesthetics and function to create a user experience is the goal of interaction design. Thus far, that goal has been difficult to achieve because a tension exists between supporting the creative process and, at the same time, making sure the system meets engineering and usability specifications. Crampton-Smith and Tabor (1996) concluded "…if we are to make use of these design skills, we need to have the input of artist-designer from an early – if not the first – stage in any design project. ... The habitual model of software design – engineering first, visual representation later – makes less and less sense" (p. 40). With the designer joining the project earlier, evaluation of the process and how requirements are collected need to be reevaluated and analyzed with aesthetics more integrated into the functional and usability goals.

In interaction design, professional designers come up with the ideas of the system. There is an important step in the process that is needed to gather the users' information and determine opportunities and constraints to designing and developing it, which can be categorized as a requirements gathering phase. Whatever its form, the primary purpose of a requirements model, process or structure is to communicate—users to designer, designer to users, designer to developer—in an attempt to achieve optimal design, which is typically defined as the most desirable measurable outcome possible under a restriction expressed.

Whether designing an intranet web site or a microwave oven, designers have at least three sets of overlapping criteria to deal with: business objectives, user experience objectives, and resource limitations and timeline. To call something optimal, means the most desirable outcome of a specific set of restrictions. Optimal is achieved only through communication.

Yet, some of the difficulty and complexity in the design process is communicating perspectives and understanding. For example, which restrictions do requirements gatherers measure? How do designers define the desirable outcome across clearly conflicting objectives? What resources should be applied to satisfying which objectives?

Designers need to create workflow, diagram and design user goals, usage patterns, personas and incorporate scenario based methods. They must also apply interaction principles, patterns and behaviors into the composition. In addition to the previous elements, designers need to incorporate traditional design elements, including: concepts of form and meaning; color, contrast and emphasis; composition; typography; iconography; auditory and tactile design methods; and semiotics and signs. These characteristics are universal and are incorporated into any design solution and project consideration.

There is no perfect design, but collaboration makes an optimal design more possible. The willingness to share depends on whether individuals perceive exchanges as involving expertise, which is more socially gratifying, or a product. For example, Craig and Zimring (2000) discuss how such an exchange is perceived and argue that it depends to a certain extent on the form of the material being exchanged. A detailed drawing, for example, might be seen as a product, whereas a sketch, even if it represents roughly the same information, might be seen as expertise. Some presentations are formal, containing detailed drawings and renderings, while others are quite informal. Hence, although presentation style may be a factor in influencing collaboration, it is not likely that it has a consistent impact.

Models and Steps in the Design and Development Processes

Various models currently employed provide a structure for the steps in a development process. These models are followed in a variety of permutations, and a couple of examples are described.

One of the first models used in software engineering and interaction design of applications is called the waterfall method. It is a linear step-by-step model, in which each phase is completed before the next can be started. The name of the steps can vary, but they are typically referred to as illustrated in Figure 1.

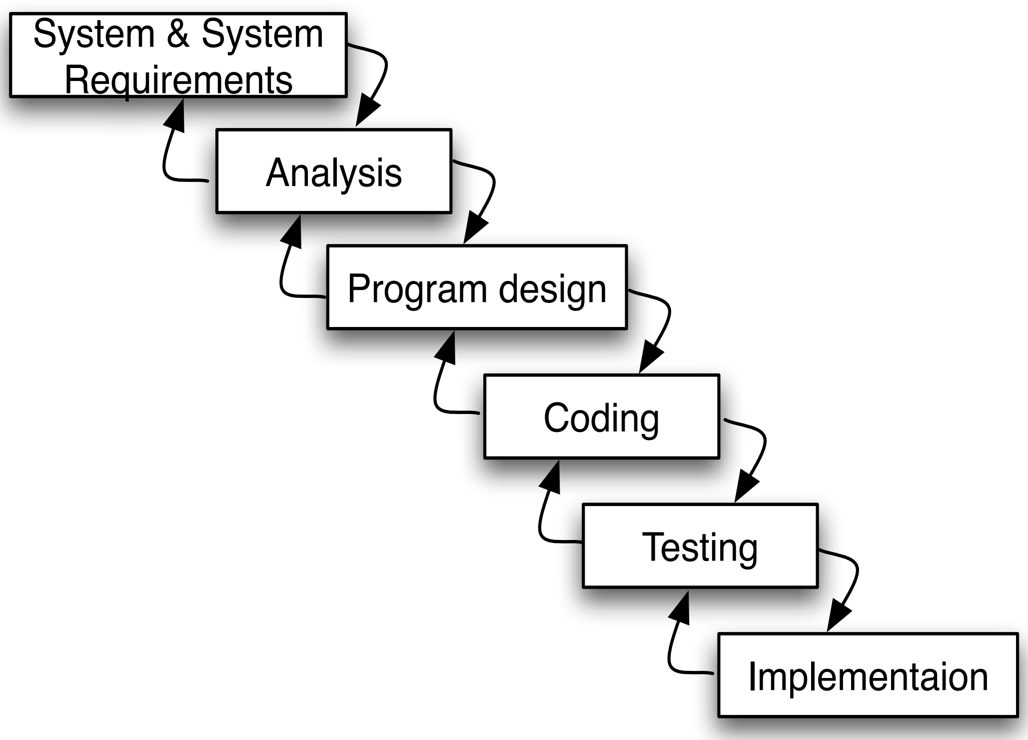


Figure 1. The Waterfall model is the earliest method of structured system development described by Royce, (1970) in "Managing the Development of Large Software Systems."

A documented weakness with the waterfall model is that requirements change over time, and freezing requirements isn't realistic for most if not all projects. Because of this, newer and more iterative models have evolved such as agile. Agile is based on iterative and incremental development, where requirements evolve through cross-functional team collaboration.

The ADDIE model is an approach to the instructional design process, similar to software development models like waterfall and agile. ADDIE is an acronym referring to the major processes that comprise the generic instructional design process:

1. Analyze: define the needs and constraints;
2. Design: specify learning activities, assessment and choose methods and media;
3. Develop: begin production, formative evaluation, and revise;
4. Implement: put the plan into action; and
5. Evaluate: evaluate the plan from all levels for next implementation.

ADDIE like waterfall does not account for iteration in the design process.

The Star Lifecycle model developed in the discipline of human-computer interaction. Its original intention was to capture the highly interconnected activities in designers' work.

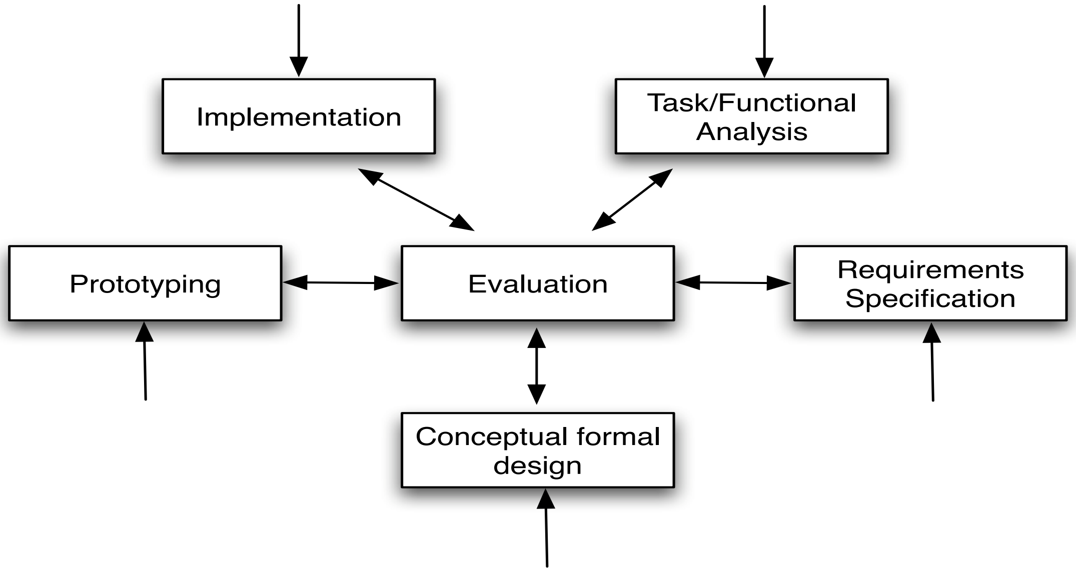


Figure 2. The Star Lifecycle Model, (Hix and Hartson, 1993).

In this model, evaluation is the first step and only when completed is it possible to move to any other phase.

The designer's responsibility is to design an interactive artifact that guarantees the audience will experience the expected outcome. These models and others like them provide a framework for teams to guide them through completion milestones. It is important to select a framework to help ensure an effective, systematic, and efficient outcome for the users of the system. The framework is used to optimize the process in selecting or developing the solution, which provides the best results of the intended goal and satisfying the user.

Although much of current research in the area of design has focused on process or the artifact developed, Reynolds (1998) wisely cautioned content experts to be familiar with the capabilities and limitations in numerous authoring tools, many of which have their own development framework, by choosing the method most appropriate for the intended audience. Although his article was written in the last century, his premise should still be a respected caution as authoring tools are just now becoming easier to use and to integrate into interaction design systems and artifacts. Reynolds says, "Designers should consider a variety of methods to present [artifacts], and, based on considerations like needs assessment, materials availability, and resource restraints, the best method should be chosen" (p. 165). For example, Adobe Flash is not always the best authoring tool when a requirement is for the content expert to frequently and easily update. In essence, researchers propose that to achieve best results requires putting interactive design into the design process earlier to enable better interaction and system and user integration. The intended user or user centered preferences and objectives should be the driving force, not the latest software or hardware tool.

Prototyping and Sketching in the Design Process

A variety of tools are used to demonstrate to the client how and what will be delivered throughout and ultimately at the end of the process. These can be spreadsheets that organize the content, wireframes that quadrant out the content areas, design mockups to capture the essence of the look and feel and prototypes to how the application will function. These tools are used to advance the process and provide guideposts or scaffolding to describe and depict the knowledge and understanding of the goal and the users intended use of the final product. They inform and communicate what is understood about the goal to the team as well as the client.

In this study, sketches, mockups or prototypes act both as artifacts showing the progression of the collaboration and demonstrate the decisions made to arrive at the final product. Historically, design research focused on the sketch itself or the tools used to produce it instead of the actual mental process or dialogue that occurs during the sketching or prototyping process. Fullman (2003) suggested that if we accept the importance of sketching in design work, it is easier to comprehend and value the argument that the sketch or design is a dialogue involving the designer and the materials of the design situation and, therefore, a reflective conversation. In addition, Fullman (2003) cautions designers to interpret that reflective conversation as part of a complete process—a search for a well-balanced whole that along with the dialogue, incorporates the simultaneous activity of Shön's (1983) problem setting and solving.

During the early stages of design typically described as the conceptual phase, sketching is widely used to record, work out and create ideas, and has been referred to as "the medium of reflection-in-action" (Schön, 1983). Designers utilize various types of media during this concept design sketching. It is common for designers for example, to generate many quick sketch ideas using traditional media, such as pens, pencils and paper. Concept design ideas are generated quickly and are used to frame not only the designer's early ideas, but also to try to better understand the problem. Schön (1983) suggests that through drawing, designers construct a virtual world where the drawing represents persona, behavior and relationships unimagined beforehand. Sketches are depictions that will often allow the designer to try out a new idea on paper, quickly and cheaply. Schön (1983) notes that its residual traces are stable and can be subsequently examined by designers at their leisure. The sketch also possesses the potential to act as both facilitator and recorder of creative acts presenting opportunities for improved evaluation and the re-stating of problems (Rodgers, et. al., 2000). The research on sketching provides an important perspective on the collaborative design process and the tools and techniques designers use in their sharing, communicating and joint designing. More research is needed to look at the sketch as a design artifact and its importance to the collaborative part of the design dialogue.

Sketches are often perceived as having a relatively low or disposable status, despite their importance in the design process; however, it is one of the most tangible artifacts produced during the conceptual activity. Typically, when a project is completed, early exploratory drawings are often destroyed and cleared away to make room on the drawing board. In the past, the importance of the sketch has perhaps been overlooked. But, because the sketch itself is part of the collaboration and the process of collaboration is important in shaping the final product, it is becoming important to create a repository or shared space to archive or store important documents, including the sketch, that can be referred to as a document of the design decisions. For example, in the design-engineering field, design repositories are emerging to replace design databases. Szykman, et al. (2000) indicated design collaboration studies rely on advancements in collaborative technology, which incorporate design repositories and metadata for archiving and retrieval. These repositories provide an additional design knowledge base and achieve a more comprehensive description of design, including function, behavior, design rules, simulation models, and more. This content will bridge the design process across disciplines and collaboration and create a shared repository that can be integrated across systems, shared and distributed.

Fullman (2003) considered sketching to be an archetypal designer activity, not just a tool or skill; rather, sketching is how designers think. Sketching is an important part of the design process and is broadly adopted in human-computer interaction; however, according to

Fullman (2003) sketching is hardly ever discussed and often routinely ignored. He asserted human-computer interaction is different from other design fields because designers need to deal with interactivity, temporality, tangibility, immersion, sound and haptics (technology which interfaces the user via the sense of touch by applying forces, vibrations and/or motions to the user). Elements like these are difficult to capture with a pen; so, designers often work in Adobe Photoshop, Illustrator or Flash—tools which create a product that is often described as a proof of concept or prototype analogous to the sketch. Prototypes and proof of concept tools are used in the design process and act as documents in the same way sketch artifacts are used to visualize the process progression. The tools designers choose to communicate their thought process are flexible and versatile. Sometimes a wireframe is sufficient, and other times a functioning prototype is necessary. Designers assess the scenario and determine the process and tools that will be used to structure the project. This is collaboratively negotiated with other team members, to arrive at the best approach and tools, to get the deliverable aligned with client and user experience expectations.

Structuring Design Processes

Problems in the design process are almost always unanticipated. Design professionals therefore think of them as belonging to the category of ill-structured problems requiring productive processes that are audience-focused. Designers have acquired skills that allow them to assess design problems easily. Their approach to the analysis portion of the design process is to parallel the known required characteristics with the iterative process that will ultimately cohere into the final product. According to Sebastian (2005), designers need an analytic system that can dissect the design process, to understand what cognitive mechanisms lead to producing it; therefore, following the process framework and selecting the tools necessary to delivering it.

Although there is research more current than Schön's, he is still frequently referred to by design researchers (Lauche, 2005; McDonnell; 2004; Poggenpohl, 2004; Stumpf and McDonnell, 2002). In Schön's (1983) opinion, too little attention is paid to the structure of design tasks and the crucial problem of linking process and task in a concrete design situation. In other words, designers cannot complete the design problem without situating it in the context where it was constructed—sometimes referred to as case-based design. The designer needs to understand the context of how the artifact will be used and the environment it will reside. Analysis is performed by evaluating existing design concepts and practices and applying them to the current design solution. One basic challenge for designers is to determine, measure and make note of single tasks and how they are implemented to make sure they are consistent with the overall approach to the final product. According to Valkenburg and Dorst (1998), Schön finds fault with the prevalent analytical framework for taking design out of context, for failing to describe unique and individual design activities and their impact on design process and practice. Schön's theory of reflection-on-action is based on a constructionist view of human perception and thought processes. That is through the execution of move-testing experiments, which involve action and reflection; designers actively construct a view of the world based on their experiences. This view of the world and the experience acquired shapes the design decisions and the final product.

According to Schön (1983), the best way to learn design is to actually design. Shambaugh and Magliaro (2001) agree with Schon and suggested that design instruction should include three elements: 1) teaching design by actually designing; 2) modeling design expertise; and 3) conducting reflective activities. Shambaugh and Magliaro (2001) asserted that the processes used by product, architectural, instruction, interface, and software designers are similar and therefore, indicate that the design process is both structured and is generalizable.

The basic elements of design activities are actions and decisions, and the kernel of design ability is to make intelligent decisions about those actions. The designers scrutinize the results of these experimental actions and react to this new state of their own making. The final design is a result of this interaction. Valkenburg and Dorst (1998) assert that in this state of reflective conversation with the situation, designers work towards labeling the relevant markers and milestones under the circumstances, framing a problem in a certain way, making moves toward a resolution and assessing the progress.

Melican (2004) suggested that design research looks at designers in the act of designing as they apply the information provided through user research in their creative problem solving process. According to Melican (2004), designers productively apply user research data in the following categories: 1) devising the design task; 2) recognizing patterns in the data; 3) framing the design problem and generating solutions to it as a result of finding structure in the data; and 4) constructing models of user behaviors, including narrative scenarios of use based on the real-world stories in the data, also known as user stories. Designers start by naming the pertinent questions in the design situation, framing the opportunity in a particular way, making decisions towards solving a particular solution, and reflecting on those moves and the current framework. Valkenburg and Dorst (1998) described this as a reflection, a conscious and rational action that can lead to reevaluating and restructuring the problem resulting in a new approach to solving the problem.

Each design participant sees the object of design differently and two main aspects balance the solution: the analysis and the creation of design artifacts. However, according to Sebastian (2005) the balance is manifested first in the analysis and creation and second in designing, which involves the purposes and roles in social circumstances. The individual designers approach and knowledge is crucial because what complicates the situation and makes designing a challenge is that designers have different experiences and different languages that are magnified by the different ways human beings relate to other human beings. For example, designers favor different design styles and patterns. Some designers prefer simple flat navigation and others prefer creating deeper relationships to content and relying on breadcrumbs for way finding. Consequently, how designers relate to physical objects, experiences, activities or services has a varying affect.

Stempfe and Badke-Schaub (2002) conclude that there are three different strains in design research: normative, empirical and design-as-an-art. The normative strain, as practiced by Cross (1989) and Cross and Cross (1995), uses systematic approaches to design to achieve optimum results, deriving from methodical study of tasks and requirements. In the empirical strain, designers rarely follow approaches described by normative studies as methodical study of tasks and requirements. The design-as-an-art theorists (such as Schön, 1983) state the design process cannot be captured or understood by any methodology. And the work of a designer resembles an artist constantly reflecting on his or her work. Designer's processes and approaches have variations. Also different design related disciplines employ different steps, tools and perspectives. Interaction design, similar to other design disciplines, leverages processes, techniques and tools for achieving collaborative production goals.

Interaction Design Research

Interaction design is one of three branches of human-computer interaction that include task-efficient design and participatory design. The difference among the three branches is in how project goals are formulated. Interaction design has multidisciplinary roots in industrial design, human factors science and human-computer interaction. Saffer (2007) describes interaction design as the art of facilitating communication between humans through products and services. He suggested its usefulness is in its application to real problems; in other words, the design of the interaction needs to provide an optimal experience as a solution to the problem.

Fallman (2003) describes the types of interaction design practiced: conservative, pragmatic and romantic. The conservative designer is an information processor with an ill-defined and unstructured problem who applies design methods through a structured process. The pragmatic designer uses a "self-organizing" approach to a unique situation and the result after reflective conversation is the outcome of the dialog. The romantic designer treats the product as a functional piece of art with an approach that is mystical, creative, imaginative and artistic.

According to Fallman (2003) the interaction design process is iterative and involves the designer in the three phases that encompass the process: analysis, synthesis, and evaluation. He also described the process as a gradual progression from abstract to concrete. Fallman (2003) introduced the descriptions used by Jones (1970) to describe the process:

analysis as breaking the problem apart; synthesis as putting the pieces together in new ways; and evaluation as testing the result and consequences of the newly arranged artifact into practice.

Fullman (2003) suggested the use of specific methods such as brainstorming sessions to help collaborators share ideas openly without criticism, and the use of specific environments to nurture creativity for improving collaborative design. He described non-interaction design theorists as suggesting these methods do not assist in formalizing and systematizing design work and others who suggest these methods as merely devices for learning new methods and extending the palette of tools for various situations.

Although, Fallman (2003) called for the need for design methods, he and other theorists assert that the outcomes and evaluation of any process will not be better than the skills and the abilities of the people that participated in the process. The composition of the design team, then, is important.

Interaction Design Team Composition

This composition of a design team may vary. Who the members are and what they are called are rarely the same. And it is common for a person to have multiple roles on the team and in the project. This combination of multidisciplinary perspective and complexity of team structure often causes misunderstandings and interruptions in the progression of the project. There are, then, roles, tools and strategies to help gain understanding in how to improve communication and support throughout the design teamwork process (Stempfe and Badke-Schaub, 2002).

As a result of one of these studies, Forlizzi and Battarbee (2004) presented a framework that provides a common design oriented frame for all relevant participants and does not rely on the single view of one discipline. The framework they propose, an interaction-centered view, emphasizes experiencing the product. The authors suggested that after a set of user-product interactions is generated with the framework, a deep knowledge of the collaborative experience through a subjective and objective view must be realized. They suggested one method for obtaining this understanding is through the use of prototypes to learn about social interactions and co-experiences.

The Forlizzi and Battarbee (2004) framework can be used to help structure the approach and focus the ideas gathered. Normally, bringing people together with multiple backgrounds can generate more designs; at the same time, different perspectives and individual values can also cause difficulty in moving the designs forward. When the process works, Stempfe and Badke-Schaub (2002) concluded that these teams will have a positive impact on the creative product and the interaction among members. Although Löwgren (2002) said interaction design is still emerging and not yet well defined in research or practice, web-design has become a natural part of the human-computer interaction field. Löwgren (2002) made three assertions about interaction design: 1) it is a discipline apart from science-and-engineering perspectives; 2) the concept of quality is not well defined and current process lacks social structures needed to develop it; and 3) human-computer interaction (HCI) may not be the best place to look for inspiration as we begin discussions about the inadequate vocabulary of interaction design. These assertions support the contention that interaction design is a design discipline, which should value aesthetic considerations along with user experience and functional requirements as characteristics to study.

The goal of design research is improving the communication required to generate innovation and coherence in design. Haymaker, et al. (2000) concluded that when multiple participants and collaborative tools and technology come together to evolve a design, the conversation and outcomes that describe meaningful information become the primary concern.

Because of this multi-disciplinary approach, social complexities in design have escalated and surpassed technical complexities. Social complexities include: collaboration in general, working from different skill and expertise levels and technical and physical barriers to arriving at a mutually agreed upon solutions. Design practice is socially complex and, therefore, the emphasis should not be on new technological inventions to solve collaboration difficulties, but on a socio-psychological approach (Sebastian, 2005). “There is a revival of the human factor, with its unique cognitive facilities, as the focal point in design and management” (Sebastian, 2005, p. 92).

Interaction designers will need to challenge themselves to keep their approaches fresh and apply similar characteristics across the team. There will need to be agreed upon goals and strategies for working in partnership, developing jointly, and collaboratively creating design solutions.

Meeting these goals help designers achieve their final product. Conley (2004) describes seven characteristics designers bring to projects to support their ability to contribute in a broader sense than the conceptual phase: 1) Understand the context or circumstances of a design problem and frame them in an insightful way; 2) Work at a level of abstraction appropriate to the situation at hand; 3) Model and visualize solutions even with imperfect information; 4) Problem solve in a way that involves the simultaneous creation and evaluation of multiple alternatives; 5) Add or maintain value as pieces are integrated into a whole; 6) Establish purposeful relationships among elements of a solution and between the solution and its context; and 7) Use form to embody ideas and to communicate their value.

Conley (2004) also asserted that organizations need to leverage the knowledge and talent that sits latent in their organization and suggests what is needed are both a more objective understanding and a command of core design competencies. In fact, Conley (2004) said design expertise has little to do with that black box called creativity. Design is a discipline with a set of competencies that can be understood in objective terms and applied broadly across organizational functions. Studies in design and interaction design are providing insight into the design process, which is highly collaborative with multidisciplinary perspectives.

Collaborative Design

Collaboration is working together, especially in a joint intellectual effort. Collaboration is an ongoing and iterative loop that enhances the quality and the speed of communication, and consequently the quality of the products created in the joint design sessions. However, most of what is known about design activity and the process comes from individual designers of studies. Multidisciplinary perspectives introduce conflict, complexity, varied skills and approaches. A brief discussion of design team conflict, learning styles and collaborative artifact contribution to the collaborative design process frames just a couple of elements that illustrate the collaborative and phased nature of the design process. Teamwork in design has been studied relatively little, even though, according to Cross and Cross (1995), teamwork is of considerable importance in normal professional design as it becomes a more integrated activity. People on all sides of the design, development and user processes have complaints about their interconnectivity. For example, designers don't understand how the tools work and sometimes design concepts can't be built formalized, or developers don't ask questions about how the design could be done in a way that makes the development easier and functional. Valkenburg and Dorst (1998) asserted that by introducing several designers, we also introduce the difficulties of team designing. These difficulties lie in synchronizing the thoughts and activities of the team members. Judging from team observations, this can cause serious problems for team members in interactions and conversations and lead to misunderstanding and uncoordinated actions.

Nieusma (2004) highlighted key themes that affect process in collaborative design practice as: diversity, disagreement, uncertainty, governing mentalities, and agency not recognizing unequal power relations. These themes describe the many ways social power influences design thinking and practice. In reaction to marginalized groups, several alternative design disciplines have emerged, such as: universal design, participatory design, ecological design, sustainable design, feminist design, and socially responsible design and they have gained varying degrees of legitimacy in their efforts to influence design for the groups they represent.

Collaborative designing is a process of actively communicating and working together to jointly establish design goals, explore design problem spaces, determine design constraints, and construct a design solution. Lahti, et al. (2004) restated that designing is generally considered a form of complex problem solving, and it is an iterative process by nature. Although there are a variety of strategies to approach the collaboration process, Shambaugh and Magliaro (2001) asserted that to teach design, there is a need for feedback between participants on both the content and process, and that the feedback between participants and experts must be genuine, continual, and consistent. In addition, the study results of the artifacts used in the development process is also an important part of reflection-about-action. Do, Gross, Neiman, and Zimring (2000) suggested that to date researchers ascribe the following roles to diagrams and drawing: generating concepts; externalizing and visualizing problems; organizing cognitive activity; facilitating problem solving and creative effort; facilitating perception and translation of ideas; representing real world artifacts that can be manipulated and reasoned with; and revising, and refining ideas.

Therefore, disciplines such as engineering, social work, teaching and design, could adopt Schön's (1983) reflection about-action and during-action, by combining design expertise and research techniques. Interactive design could adopt a reflective practicum that incorporates an ongoing cyclical or spiraling monitoring, evaluating, and revising of a design and the development of competence in design processes; however, this process should not exclude the artifacts produced during the process.

Gilbert and Driscoll (2002) discovered a key principle guiding the design of knowledge-building communities in that the artifacts or objects produced by the participants are not just submitted for evaluation, but become public materials that support the goals of the community and its individual members. The resulting data and archives provide a database of information produced by the members and is a visible sign of a substantiation of the community's advancing understanding, knowledge and proficiency.

The Gilbert and Driscoll (2002) characterized knowledge-building communities as having four primary traits:

- A focus on knowledge and the advancement of knowledge rather than tasks and projects;
- A focus on problem solving rather than performance of routines;
- Dynamic adaptation in which advances made by members of the learning community change the knowledge conditions requiring other members to readapt, resulting in continual progress; and
- Intellectual collaboration as members pool intellectual resources, making it possible for communities to solve larger problems than can individuals or small groups (Gilbert & Driscoll, 2002, p. 60).

This emerging interest is concerned with the design of tools that contribute to collective activity, and is characterized by genuine, collaborative work facilitated through the use of computer mediated collaboration. Design advances with collaboration and consensus building during the process negotiation and artful persuasion occurs to arrive at crafted and creative solutions.

Constraint and Negotiation in Collaborative Design

Designers who frequently work on collaborative projects experience working sessions concluding in unexpected outcomes and changes based on others perspectives and experiences. Attempts to plan and anticipate project outcome are many times derailed or undocumented, and because multiple perspectives are involved, unforeseen digressions occur. Joint design sessions rarely follow their original plan because when people get together, there is disorder, mistakes are made, and discussions detour. Yet, this apparent chaos can stimulate inspiration and techniques can be used to guide and facilitate the group to follow through on achievements. Godschalk and Paterson (1999) assert that within the architectural field, a generally accepted process of consensus building develops through three phases. First, pre-negotiation, including forming the stakeholder group, securing a neutral location, setting ground rules, agreeing to an agenda, and agreeing to joint fact-finding. Second, negotiation, including inventing options for mutual gain, packaging and writing agreements, binding parties to their commitments and to ratification. Third, implementation, including linking agreements to formal decision-making processes, monitoring conformance, and renegotiating as necessary. Unless, experienced in collaboration, design groups typically aren't armed with tools and techniques for negotiating and prioritizing requirements issues or conflicts. Therefore, designers need to practice collaborating with each other and peers from other disciplines to prepare deliverables in the form and method in which they are given to clients. Experience in collaboration can provide a check and balance that resolves different perspectives and polishes the negotiation process prior to the client receiving the prototype or final product. Chiu (2002) concluded that the emerging role of technologies in the design process necessitates change in the design orientation and program. Although, there is little research on the management of design teams emerging observations are highlighting the importance of collaboration, conflict and negotiation.

Conflicts are natural where viewpoints diverge, but success is the result of orchestration, not simply organization. Design team members have to be capable of making tradeoffs that cut across disciplines, sacrificing certain things to enhance others for the greater good of the entire audience experience. To collaborate in design requires being open. For example, it is one thing for a developer to write a piece of code, and throw it over the wall to the test team; it is another for a designer to design them alone and throw it over the wall to the other stakeholders.

Learning in Collaborative Design

The things designers know are entwined with the things designers do. Scribner (1985) addressed how knowers use their knowledge to operate in the world and accomplish things. Scribner (1985) subscribed to the activity theory Vygotsky (1978) framework which proposes that cognition and behavior need to be considered together. Analysis should begin with “culturally organized human activities” (p. 199). Scribner’s approach was to represent knowledge as integral to activities, technologies, and functional skills systems. Scribner’s (1985) studies focused on how action guides the acquiring and organizing of knowledge.

As designers work together they are learning together. As proposed by Lave (2007) this model of learning is called situated learning and suggests learning is contextual, embedded in a social and physical environment. Sometimes described as just-in-time learning or on-the-job training, in situated learning, designers and developers are frequently required to learn something new from each other, allowing them to incorporate some new function or concept that makes the final product better for the users. This learning is also characterized as a community of practice where the acquisition of knowledge emerges from the relationships and connections made to understanding the problem and what is needed to improve the process or make it more functional. Knowledge is created and negotiated through the interactions of the professionals with others and their environment. Collaboration and group learning is a cooperative and participative method of acquiring knowledge. Proof and demonstration of this group and participative process are the design artifacts produced throughout the advancement of the process.

Design Artifacts as Elements of the Collaborative Design Process

The importance of artifacts and their role in the traditional design process was discussed earlier. Artifacts and communication tools that capture interaction, for example, iChat and Adobe Connect, also play a role in the collaborative design process. As demonstration, pen and paper sketches, tables of data, guidelines, paper and Adobe Photoshop or Flash visualizations, and visualizations produced by drawing applications or simulation and concept ideation through wireframes and prototypes all play a role in the collaborative design process. In interactive design, design artifacts, such as plans, models, prototypes, and visualizations, and procedural artifacts, such as forms, change requests, office memos, letters, schedules, and Gantt charts also play a role in the design process. Design artifacts represent a designer’s thought about a design, whereas procedural artifacts convey the anticipated design process and help orient consumers of the design to it. Do, et al., (2000) proposes that previous designs are used to generate alternatives and to predict the outcomes of new proposals by applying transformations to various design objects. Previous designs suggest possible solutions, frameworks and design strategies. The authors found that the designer plays games by defining rules, selecting strategies and design moves from these self-imposed rules, and discovers and evaluates the outcome. As a result each of the design elements was transformed throughout the design process.

Perry and Sanderson (1998) described a variety of tools used in the collaborative design process that they consider participants in the design process. These include common design tools (pencil, paper, and calculator), drawing tools (CAD and plotter), activity and co-ordination management tools (Gantt charts), information management tools (common filing cabinet, large table surfaces), calculation tools (spreadsheet, specialized applications), communication tools (telephone, fax, whiteboard, a window that opened), prototypes (cardboard model, prototype pump, parts stockpile), and testing tools (digital test rig, competitors' pumps, stroboscope, camcorder, thick liquid). In addition, tools used for collaboration also act as procedural artifacts in the collaborative design using interactive technology. Tools and techniques for collaboration include negotiation and interaction such as: e-mail; conferencing; discussion, presentation, role-play, debate, panel, expert opinion; collective understanding; synchronous, asynchronous; collaborative knowledge building; Knowledge Forum, and Whiteboard. Design work can no longer adequately be conceptualized in terms of individual intelligence, nor as a linear process with a set of design stages, but rather as a situation in which joint, coordinated learning and work practices evolve, and in which artifacts help to mediate and organize communication.

Communication in the Design Process

Satisfying all possible users requirements, regardless the user’s and the designer’s business knowledge, is usually not possible; however, it is the desired goal. Therefore, the effectiveness of design communication becomes critical for designers: especially in sharing design information, decision-making and coordinating design tasks.

Chiu (2002) found five important conditions for effective communication during the design process:

- Three kinds of communication should be considered, including human, data, and network;
- There are different levels of communication–individual, group, and project;
- The participation and conditions for coordination among individual members of a design team are critical for communication and representations, and design task dependency defines data dependency and the information flow; and
- Effective communication usually occurs among the smallest number of people in design organization.

Finally, all participants share common goals and the process in design communication is cyclic until the goals are achieved. All of these communication conditions affect decisions; since these decisions involve many domains and perspectives, to include all of the conditions with equal rigor requires a very complex set of considerations. Collaborative design teams not only rely on technology to create artifacts, they work in different physical locations and leverage technology to facilitate the iterative process.

Collaborative Design Teams and Technology Research

Design teams work on location with clients, collaborate with professionals in other organizations and use technology to overcome physical boundaries to their collaborative process. These collaboration tools introduce benefits and challenges to the design process. Linder and Rochon (2003) assessed from the research literature that synchronous computer mediated communication (commonly referred to as internet chatting real time) has important benefits over face-to-face communication. There is more balanced distribution of participation among learners, increased language production, and reduced of anxiety. In addition, Linder and Rochon (2003) identified six steps that provide an overview of the process they suggest for the formative evaluation of implementing co-operative use of tools for a team:

- Description of the original design event;
- Prediction of collaborator behavior during the sessions;
- Documentation of the actual behaviors displayed during the sessions;
- Comparison of intended behavior with actual collaborator behavior;
- Interpretation of the discrepancies between predicted and observed behaviors; and
- Recommendations for re-design and/or revision of predictions of collaborators behavior.

Technology is advancing and evolving along with designers use and practice creating many more opportunities for research to better understand the complexity technical tools introduce into the already intricate and iterative design process.

Collaboration Technology Studies

Previous studies focused on issues of design collaboration including the process, team work, the design settings, groupware, communication patterns, and pedagogy. In addition, a number of examples of collaboration research exist that were conducted while examining e-learning to inform collaborative design and development. A few researchers, (Hiltz, 1997; Sherry, 1996), who studied online courses observed that while communication options (e.g., e-mail, bulletin boards, conferencing systems, whiteboards, chat rooms, and videoconferencing) are plentiful, but increasing internet-based-instruction (online courses) has focused mainly on student-content and self-study lessons and materials. As Moallem (2003) observed, learning is an act that is, in the end, dependent on individual effort. However, participation of the individual in a group with the same learning objective can facilitate an associative collaboration of learning by each individual in the group. Nonetheless, researchers have paid little attention to the social dimension of learning in online courses or Internet-based instruction.

The social dimension of learning presents two issues. First, that not enough research is available to measure collaboration in general to provide practices for when, how and what technology to use for presenting, discussing, negotiating or modifying. Second, this research has predominantly been about student learning or student designers, for which the motivation and incentive to collaborate is probably lower than that of non-student design practitioners.

Design practitioners typically use email, Internet messaging, electronic whiteboards and graphic design tools to collaborate on their work. Now they are considering different tools (e.g., document markup and comment tools) and have a degree of motivation towards adopting them because they are more integrated into their design and review process. However, more research is needed to determine how and when these tools should be adopted. In collaborative design, designers are using these technologies to support communication by defining: 1) tasks and process dependency; 2) data dependency; 3) visualizing the design process; and 4) supporting team awareness. Chiu (2002) describes the requirements for each of these technologies:

1. Task and process dependency: the collaboration or CSCW system defines participants and their tasks in the process, and supports three levels of communication among individual, group, and project. Therefore, task and process dependency can automatically promote interactions among participants.
2. Data dependency: the system defines data dependency based on a combination of the reference, documentation, project management, and communication systems, thus design information can be generated, stored, and shared.
3. Visualizing the design process: the system traces the status or progress of project by visualization to detect possible communication pitfalls.
4. Supporting team awareness: group participation in design collaboration is a social process, and the system is used to enhance the personal identity and team awareness in the process by demonstrating participants' presence (Chiu, 2002, p.192).

More research is needed to explain this practice and the contribution it makes to the collaborative design process. Technology can provide a system of record to contribute to the knowledge sharing and knowledge transfer of the process designers use to gain skills and produce their projects.

Social Discourse and Collaboration

Social constructivists emphasize that through sharing of ideas, people modify their previous knowledge because knowledge is not only formed within an individual's mind, but also constructed through social interactions. Vygotsky (1987), for example, said learning is a social construct mediated by language and social discourse. Conceptual change and knowledge gain is facilitated through the construction of shared outcomes or artifacts that learners engage in developmental cycles to produce. The social view of interactivity places emphasis on a collaborative and cooperative learning environment and encourages active dialogue. In such an environment learners are exposed to multiple perspectives that form cognitive scaffolds as people exchange information with each other, the people around them and experts in the field.

Social discourse demarcates the process of negotiating meaning. Progress has been made in knowledge management to provide archive ability adding important criteria for cross-referencing an object to be easily cataloged, located and retrieved for future use. This progress is an important emergence in tools and resources used for collaboration with multi-disciplinary teams. Design teams are beginning to build a reliance on these Knowledge Management Systems (KMS) databases with archiving and cataloging capability. KMS are an evolution of design databases or repositories, and act as a universal translator and bridge that cross-walks terminology matching tools, language and labels from different disciplines. As designers and developers begin to use design repositories such as KMS, Spector (2002) suggested it will be worthwhile to study interaction patterns and perceptions about the relative merits of collaborative work.

As established in collaborative research with cross-discipline teams, there are many small issues yet to be resolved, such as how to facilitate alternative design or development paths using the same underlying set of documents and artifacts. Spector (2002) posits KMS technology should allow what-if analysis of alternative designs and implementations with reversion to earlier versions or to mixed versions. This kind of hybrid prototyping, although it is a common design methodology in other settings for example, engineering design is emerging as a method to quickly demonstrate to clients design decisions and directions.

Summary of the Literature

The practice of and research about interactive design it is relatively new to the design community. In addition, interactive design is evolving, and recent research mentions the importance of both design and design skills required to build the types of projects and electronic resources currently being developed. Furthermore, research in design environments – usage, development and learning – all call for multidiscipline design expertise and provide studies that have called for design experience, collaboration and design approaches to artifacts. Studies in design provide insight into both collaborative and design development processes and provide initial data that inform design collaboration in practice.

Specific to collaborative design, a number of studies using students as participants in the experiments have been conducted around early design stages or episodes, mostly in the planning and conceptual phases of the design process. However, little research has been done about where the interactive designer plays a role and when the designer should be brought into other project stages.

Another area that collaborative design research has explored is the role artifacts play in the design process as elements of communication, sharing and task negotiation and constraints, and how artifacts are used for validation and discussion as well as tools to refer or present ideas that foster more or different directions the designs can take. The role interactive designers play, how they interact and collaborate with other team members using collaborative technology is the focus of this study.

Chapter 3

Research Method

This chapter outlines and discusses the research approach used in this study. The inquiry was based on activity analysis of small teams working on an actual design problem in a work setting. The Function-Behavior-Structure (FBS) was used as the generic protocol analysis scheme (see Figure 4 for Protocol steps Table 3 for FBS coding framework and Figure 7 for FBS ontology in later sections in this chapter). The research sought to describe a design team's process of collaborating and problem solving and to satisfy client requirements. Through this research, the team's process was analyzed and as client requirements were discussed and negotiated among team members. The study was based on the observation of a practicing interaction team and data for the case-based study was coded from the teams' sessions and used for comparing the same team collaborating on two similar projects. The design of the study section, describes the method used in more detail.

Research Question

The study design and selection of analytic method is guided by the following question:

> Are there identifiable distinctions in how multidisciplinary design teams approach specific tasks that comprise the design process in their problem-solving and task-setting processes?

The role of the designer and the manner in which team members contribute to shaping and establishing creative direction in a cross discipline collaborative process while working on an interactive design project was observed. As the process moves from analysis and design to development and the developer begins to interpret the meaning, the study observes the collaboration and negotiation that occurs between designer and developer to result in an implemented project.

The study itself was guided by several questions and the results are discussed in Chapter 4:

- Can protocol analysis describe the cognitive and development process of designing?
- Is protocol analysis the most promising method for clarifying design-thinking behavior and providing the framework to describe the designer's role in web development and functional specification?
- What can verbal reports of thought sequences tell us about the role design plays in interface design projects?
- Does the process vary from individual to individual?
- Does the process vary from project to project?
- Does the designer's role in the design process on the project influence the outcome?
- Can the data gathered supply information to improve the design process?

To analyze the collaborative design process, team members' work was observed on two projects and recorded and coded to specific behaviors as the designers and developers discussed and negotiated the interactive design solution.

Team members used a variety of tools throughout their day to communicate and collaborate beyond face-to-face meetings. The additional collaborative design work outside the sessions was done by email and chat, exchanging feedback, documents and diagrams. The design team's current process does not keep track of documents, sketches or communication that occur during the process. Without a repository or tool to capture or document this workflow, it was difficult to reconstruct and observe the entire process, an area of opportunity for future research and projects. With the aid of information technologies to capture these collaborations and interactions, this study records, reconstructs and documents the collaborative process. The use of these tools prompts one additional question to explore:

- When using technology to aid the process and to collaborate and communicate, what are the outcomes, issues, pitfalls and benefits?

Assumptions

Referring to the primary research question previously restated, it was possible to craft a more specific statement of expectations that guided evaluation of the approach to design activity analysis and description adopted in this case study. The following are some assumptions based on the data collected.

In describing and documenting group design activity, distinct patterns were identifiable in how observed design teams used or applied different collaborative techniques and task-setting procedures in their problem-solving processes. Based on protocol analysis and the categorizing of the processes (FBS framework and ontology) after coding, these patterns reflected distinct types of work effort in the data regarding the subjects' behaviors. These behaviors were measured by critical activities and cognitive design process during the study of an interactive design teams six meeting sessions. The team demonstrated additional information related to design activities not found in face-to-face discussions that required only individual work such as mock-ups and research on design patterns that were then brought back to the group either informally through chat and email or in the face-to-face sessions. Design teams employed a variety of tools (creative brief, wireframes, site map, flow diagram and design directions) to move their product through a process that resulted in the final product. The methods employed in this case study yielded descriptive results of that process. The description of creative design problem solving, as practiced by groups, constituted a valuable result that may be further analyzed toward a variety of ends. The results from this study can be used to compare with other studies that used the same generic scheme.

Area of Research and Research Approach

The area of focus in this research was the convergence of human interaction and creative collaboration among different members of a design team and the structure of support and phases used in building and working together on a project. The intention of the case study was to use a generic (FBS) ontology to describe in depth the design process and the conditions and factors influencing this process. The team's work reflects different perspectives and the social and material context of the process. Roles and directions based on group decisions for producing a project were reviewed. The FBS ontology yielded quantitative and qualitative information through a protocol analysis coding scheme. This method of studying human design processes brought structure to the unstructured data without detracting from the rich qualitative data gained from investigating the process of designers designing.

The case study observed a cross-discipline interface design team as they developed two projects. How participants used technology to share ideas, information and tasks was observed. The immediate goal was to increase understanding of collaborative design practice by observing group dynamics as the team performed and delivered necessary work. Two impartial, observers who had no connection to the interface design team and who were selected because of their skill in recording and observing research were used. They transcribed the protocol analysis phase to execute the Delphi method for triangulation. These two impartial observers documented and categorized the design team's process using video, journaling, and direct observation. The goal was to observe team collaboration and increase understanding of the collaborative process to gain efficiency and identify any potential areas for process improvement.

The resulting project's final phase was interface usability testing with the client, which was recorded. Areas of difficulty in navigation or function were observed and compared to video taken during design and development to identify requirements issues and was resolved for the final release of the product.

Qualitative Research

Interaction design and design practice are complex disciplines that require applicable approaches to study. A significant amount of design research has used qualitative research methods (Button, 2000; Lahti, et al., 2004; Rodgers, Green, McGown, 2000; Strickler and Neafsey, 2002). As was noted in Chapters 1 and 2, a number of design production and process studies have been performed outside the design profession in areas such as cognitive psychology and artificial intelligence (Bayazit, 2004; Hayne, Smith and Turk, 2003; Neo and Neo, 2002; Sebastian, 2005; Storkerson, 2003). This area of research, the human interaction and creative process through collaboration between different participants of a design team, is commonly analyzed using qualitative methods because it includes human experiences that cannot be easily quantified. Nonetheless, user-centered design, computer operation, and engineering are common to human experience. Recently, research has been conducted using a combination of quantitative and qualitative research which employs varying approaches and interpretations to protocol analysis. The FBS ontology as a generic protocol analysis coding scheme was introduced as a method to generalize and standardize design research across disciplines (Kan and Gero, 2009). Accordingly, this methodology provides an opportunity for rich data collection to gather the most information possible without additional studies or data gathering from projects of a larger scale.

Design Study Overview

This case study is designed to generate a description of design activity through observations of an interaction design team in action, to capture techniques, tasks and steps performed by designers and developers, and to document the design team's decisions during the problem-solving processes. The study describes and represents information about experience through observation of the practice. The protocol analysis method, employed in this study produces descriptive results detailed later in this section of the paper.

Using (FBS) protocol analysis, the activities were coded, quantified and linked to provide correlations that resulted in quantifiable data and insight into how designers design. The generic coding scheme applied consisted of function (F), expected behavior (Be), behavior derived from structure (Bs), structure (S), documentation (D) and requirement (R) codes. The protocols were segmented according to six categories. Utterances that did not fall into these categories were coded as others (O) and included jokes, social communication, and colloquialisms. Others (O) were omitted from the quantitative and qualitative results presented.

This framework did not assume any particular number of participants being studied. It only abstracted and described the designing state of affairs in terms of FBS design issues of a segment. The aim of this simple generic coding scheme was to capture some fundamental designing aspects which formed a foundation for further analysis.

Design Projects Description

This research project involved studying interaction between humans and systems. Two interfaces that delivered information in the form of a content system and bridged the web site and the user-centered interaction. The projects were complex in their content submission and content navigation. Both projects were innately multifaceted because they incorporated alternative and potentially conflicting perspectives on how to approach the content creating and submission as well as the intended audiences navigation. Therefore, these projects were ideal candidates for a group design project that benefited from a multidisciplinary design team with interface design experience. The two projects available for current study at the time of this research were the design of a 125-Year anniversary interactive timeline web site and the undergraduate enrollment view book for engaging high school students as college prospects. These projects were comparable in scale and scope and required multiple team members to collaborate on design and development. They were also client requirements intensive and required analyst and project management skills to facilitate and structure the projects. The use of technology to capture client requirements and team collaboration proved to be of some help in documenting the steps taken to arrive at the proposed design for both the post design and usability meetings. Details of the data and project background such as audience, competitors and other information are included in in Appendix B.

Study Scope

The main method of inquiry for this research was protocol analysis. Preparation for the research consisted of selecting two similar design projects. Three face-to-face sessions were scheduled with design teams, which were video recorded. In addition, observations during the face-to-face meetings were recorded and any artifacts created were collected to dissect indirect data generation that occurred. Team collaboration between meetings about the projects were conducted online using Adobe Acrobat Connect Professional or iChat, and the meetings were recorded so they could be searched for examples of critical events that shaped the decision process, decisions and outcomes.

Clients performed usability testing on both projects and their sessions were recorded. Client interactions and questions were observed and tracked, and narration was captured.

Protocol Analysis

The data analysis method applied to this case study abstracted and described the state of designing by observing and coding verbal communication using the FBS structure, a general framework of protocol analysis. The steps followed to execute the research are further described in Figure 3.

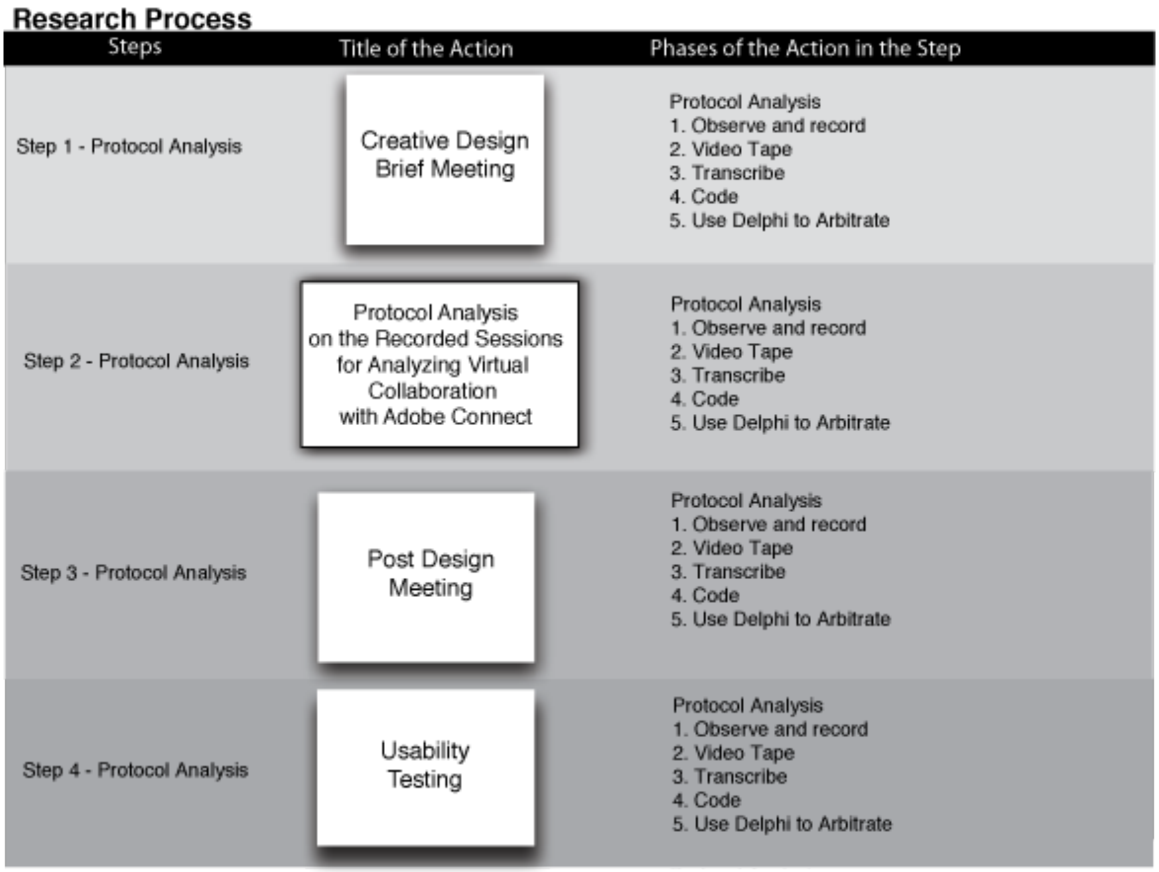


Figure 3. Research steps.

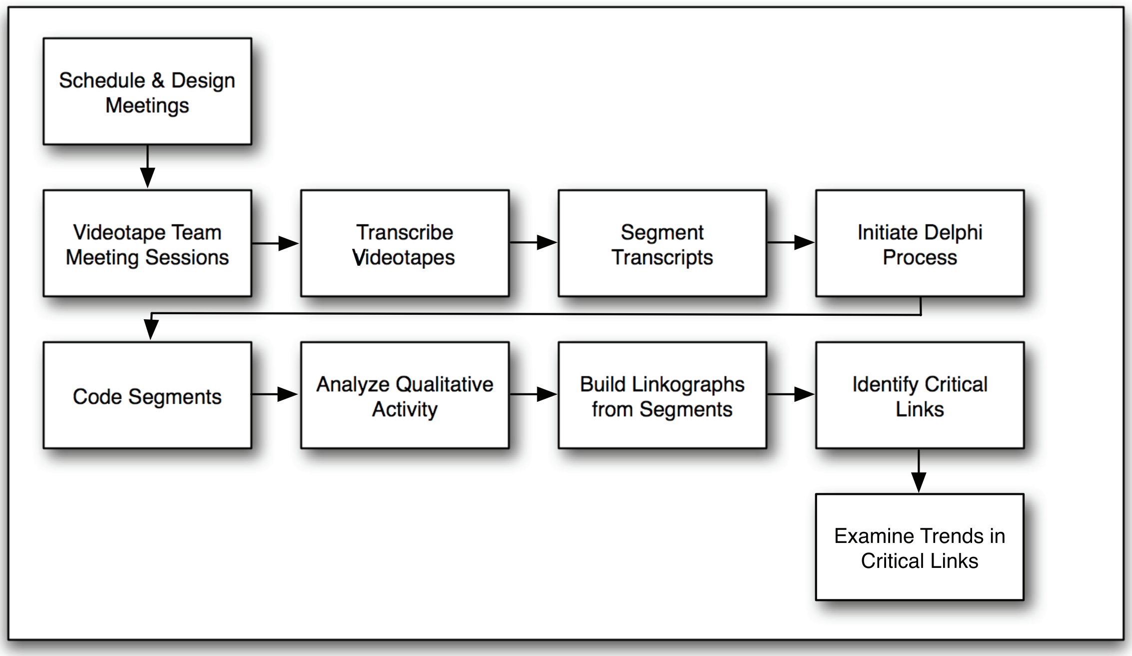
Protocol analysis coded the protocols; verbal data and other activities that demonstrated a step, act, or operation that transformed the design situation. The connection between segments and codes using this coding scheme was one segment per code and one code per segment. This connection formed the basis for segmentation and quantified the amount of effort spent by the team in relation to (F) function, (B) behavior, or (S) structure.

A design description was not transformed directly from the function but was a consequence of a series of design processes among the FBS variables. Once coded, the segmentation was imported into LINKOgrapher 1.0 (Gero and Pourmohamadi, 2011) and the output described general statistics, Markov Model, issue, semantic and syntactic process distribution results about the protocols. Semantic information was used 1) to explore different aspects of designing according to the focus of interest; and 2) to locate different types of design transformation processes. Syntactic process distribution is an approach that produces a model of design activity and relies on the sequential order of the design issues to generate links and to produce the design process. Syntactic process assumes that any segment is cognitively related to its immediately preceding segment and is a consequence of a design process that transforms one into the other.

A linkograph was also generated showing relationship patterns by using dots and lines to represent two related events. The linkograph can be seen as a graphical representation of a design session that traced the associations of every design move. Depiction of these dots and lines showed the trend of events building on previous events and provided a method for observing the pattern of communication as the session progressed.

A few researchers, Goldschmidt (1992), Van der Lugt (2003), Dorst (2004) and Gero and McNeill (2006), have used this method and the results were analyzed both qualitatively and quantitatively. These researchers asked a designer to think aloud while performing a design task and his or her actions and verbalizations were recorded for later analysis. Using protocol analysis it is possible to observe the design process in detail. In particular, it is possible to observe the temporal aspects of the design process.

Protocol analysis was used to capture and represent the design process as a sequence of events in time. The analysis techniques were extended through the use of a domain-dependent coding scheme based on generic models of design and a coding methodology based on the Delphi method for arbitration. These techniques allowed one to bring quantitative structure to the qualitative data that was collected during a design episode, facilitating the articulation of multiple aspects of the designer's behavior. Figure 4 describes the process steps of the executed to complete data collection and coding.



Gero and McNeill (2006)

Figure 4. Protocol analysis steps.

Linkography

Linkography patterns are reflected in the clustering of acts in the form of "V"-shaped chunks. Observation measures the data qualitatively to study observed acts in their context, linking is valuable to validate and verify results around time spent at different segments of the process. Understanding the content and context are intrinsically important in this type of analysis.

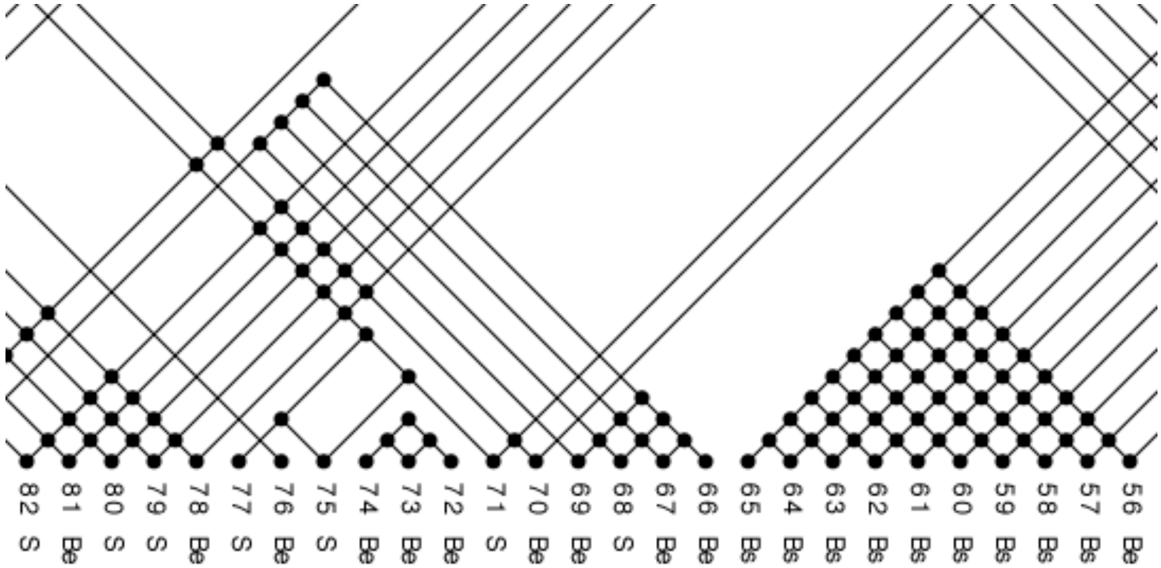


Figure 5. Linkograph from 125-Year timeline meeting 1.

Linkography was first introduced to protocol analysis by Goldschmidt (1992) to assess designer productivity. The design protocol is decomposed into small units called design moves. A design move is a step, an act, or an operation, which transforms the design situation relative to the state in which it was prior to that move.

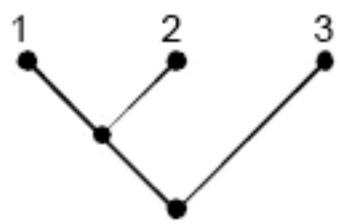


Figure 6. Goldschmidt (1992) linkograph of forelink and backlink.

To demonstrate the meaning behind a linkograph's points and lines, Figure 6 shows a linkograph with 3 moves. Both moves 2 and 3 are related to move 1, but move 2 and 3 are not related. Backlinks tend to signify analysis, verification, evaluation, assessment, and refinement. Forelinks indicate new ideas, proposals, prospects, and even breakthroughs.

For quantitative measures, Goldschmidt (1992) uses the number of links relative to the number of moves a (link index) as an indicator of the strength or productivity of the design process. She also uses moves with intensive links, critical moves, and sequence of critical moves or critical paths to compare different design processes.

The criterion for linking events in linkography is an examination of the possible connections. Sometimes this is hard to discern, especially when these steps, acts or operations are a mini-conclusion of what has happened so far. To date, linkography is an established method of analyzing team design activities both qualitatively and quantitatively (Cross, 1986; Dorst, 2004; Gero, 2005; Gero and McNeill, 2006; Goldschmidt, 1992; Suwa, Gero, Purcell, 1998; Melican, 2000; Van der Lugt, 2003).

Kan and Gero (2005) assert that coding how links are established will provide an understanding of collaborative design that shows the percentage of engagements with different kinds of activities. They also expect link coding to provide a common ground to compare face-to-face collaboration and computer-mediated collaboration. Kan and Gero (2009) later established categories and a means for measuring design process that included issue, semantic and syntactic distributions. This study followed and applied their method.

A number of studies have been conducted using protocol analysis (Cross, 1986; Dorst, 2004; Gero, 2005; Gero and McNeill, 2006; Goldschmidt, 1992; Suwa, Gero, Purcell, 1998; Melican, 2000; Van der Lugt, 2003). Researchers conducting these studies attempted to describe and study design team activities and thought processes in action. Protocol analysis, a method which analyzes data from verbal utterances, has emerged as the preferred approach.

A common criticism of protocol analysis is that the protocol is generated through group activity and therefore is somewhat controlled. There exists the premise that the thought process of the subjects is potentially influenced by the requirements of the situation and not as they occur to the subjects individually or in the form in which they occur. For example, a more experienced or group-dominating designer can influence the design decision and derail or control the process. Although this can be a valid concern, it remains the best possible method for studying design processes.

FBS Ontology

As described by Melican (2000), protocol analysis is the study of an activity from which a set of rules is created. The procedure results in a record of information illustrating activities that allows for the reconstruction and observation of that action. In this research, the process of taping, transcribing, developing a code, coding and analyzing data as outlined by Gero (2005) was followed. Gero's FBS coding scheme had not yet been used for interaction design, but was a versatile and general ontology with applicable protocols for this process. The scheme brought structure to the protocols unstructured data without detracting from the data value. The conceptual design process analyzed for this study involved the designer navigating through an abstract problem while utilizing various strategies to detail and realize the problem description. It was necessary to project a framework onto the data to obtain the detailed understanding and Gero's FBS framework was useful for that purpose. The framework derived both from direct observation of the designer interaction with the problem domain and from models of design reasoning from Gero (2005) and Gero and McNeill (2006). The designer worked through the parameters and boundaries of the problem that according to Gero (2005), involved function, behavior and structure:

- Function was for the goal or purpose of the artifact;
- Behavior related to the actions or processes of an object or artifact; and
- Structure involved the manipulation of objects or their relations to bring about a physical solution.

These categories formed the FBS scheme, allowing one to code cognitive actions of designers from video/audio protocols systematically. The protocol analysis method was used to analyze the data and to produce evidence of the cognitive processes of interface designers and developers. According to Gero and McNeill (2006), the model of design reasoning with function, behavior and structure can be differentiated for any design phase or episode independently of the design problem, but the categorization should be based on the specific design problem. For the selected projects in this research, two design problems were recorded. The design episodes form most of the process from concept to production of the overall design of the interface system. The coding framework followed for interaction design to frame the data is in Table 3.

Table 3

FBS coding framework

Function Behavior Structure		
R	Requirements	The designer is modifying or reconsidering aspects of the initial requirements.
F	Function	The designer is working with the function aspects of the problem domain.
Be	Expected Behavior	The designer is working with the expected behavior aspects of the problem domain.
Bs	Behavior Derived	The designer is working with the derived structured behavior aspects of the problem domain.
S	Structure	The designer is working with the structure aspects of the problem domain.
D	Design Description	The designer is working with the documentation aspects of the problem domain.
O	Other	The designer is working with aspects that don't fall into these categories.

Syntactic and Semantic Distribution

This research used three basic, non-overlapping, classes of concepts called design issues: 1) function or purpose (F), 2) behavior (B), and 3) structure (S); along with two external classes: design descriptions 1) (D) and 2) requirements (R). From this perspective, the goal of designing is to transform a set of functions into a set of design descriptions listed in Table 3. The function of a designed object is defined as its purpose or goal for existing; the behavior of that object is either expected (Be) or derived (Bs) from the structure (S) that results from the elements of an object and their relationships. A design description cannot be transformed directly from the functions, which must undergo a series of processes among the FBS variables as illustrated in Figure 7.

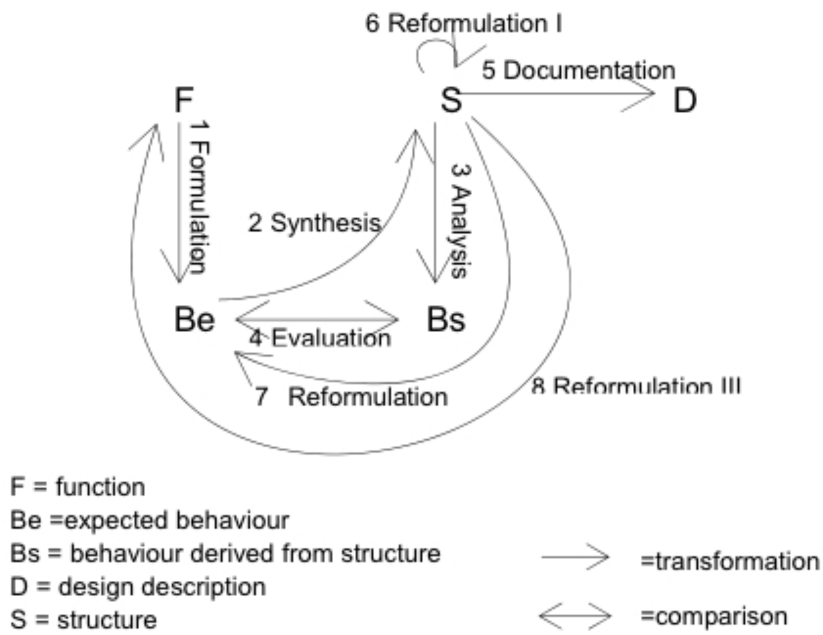


Figure 7. Kan and Gero (2009) The FBS ontology of designing.

Traditional design models iterate the analysis – synthesis – evaluation processes until an acceptable design artifact is constructed. The addition of three formulation types is to expand the design state space so as to capture the innovative and creative aspect of designing. This is a relatively new addition to the model intended to reflect more specifically the movements from one variable to another, and it is described in Table 4.

Table 4

FBS Processes

Eight Separate Processes of FBS Ontology		
Formulation (1)	R > F, F > Be	transformation of the design (R) intentions, expressed in term of functions (F), into expected behavior (Be)
Synthesis (2)	Be > S	transformation of the (Be) expected behavior into a solution structure (S)
Analysis (3)	S > Bs	derivation of "actual" behavior (Bs) from the synthesized structure (S)
Evaluation (4)	Be < > Bs	is the comparison of the actual behavior (Bs) with the expected behavior (Be) to decide whether the solution structure (S) is to be accepted
Documentation (5)	S > D	is the production of the design description (S/D)
Reformulation I (6)	S > S	S/S), addresses changes in the design state space in terms of structure variables or ranges of values for them
Reformulation II (7)	S > Be	(S/Be) addresses changes in design state space in terms of behavior variables
Reformulation III (8)	S > F	addresses changes in design state space in terms of function variables

The designer's actions and intentions are the center of the method and the protocol is divided accordingly. The understanding of the gesture, action, and word of the designer's intention is the marking device for each segment. A new segment in the terminology corresponds to a change in intention and flags the start of a new segment.

These process issue distributions are analyzed in two different ways: syntactically and semantically. Syntactic issue distribution describes the transitional processes between code pairs and related codes are described by their position in the sequence. Semantic issue distribution describes the construction of the vertical distribution of nodes as an index for the overall distance of the links (how far the linked segments are apart); the unstructured nature of the design sessions.

Delphi Method

The Delphi method was used for coding in this study because it is a process for forecasting that consists of at least two rounds of analysis. This method uses experts to predict results. Each coder makes a first pass of the transcript, segmenting and coding concurrently. During this pass the coding column is completed.

After a break of about ten days, the coder returns to the protocol. The second pass is completed in the same way as the first pass without any reference to the first coding result. The first and second passes are completed quite quickly with any sections that are ambiguous appearing as discrepancies in the subsequent arbitration process.

After an additional ten-day break, the coder compares the two coding results and performs a process of self-arbitration. When the two protocols agree the result is copied onto a third protocol form. Where a section has been coded differently in the two protocols the need to examine the section more closely is signaled. In rare circumstances the result may be quite different to the first two coding results. During the arbitration process the coder consults the transcript, referring to the video only when it is necessary to clarify the subject's actions.

The two coders combine their results in a joint arbitration process, similar to the self-arbitration. When there is disagreement, each coder offers reasons for his or her particular result. An arbitrated result is achieved by a consensus approach. When all three results from one coder (first and second passes plus the self arbitrated result) are the same there is a strong assessment attached to the result that can make the joint arbitration process easier. The joint arbitration process is applied to the first three dimensions concurrently. The Delphi method triangulates the data because two different and objective coders perform the coding. An illustration of the process is depicted in Figure 8.

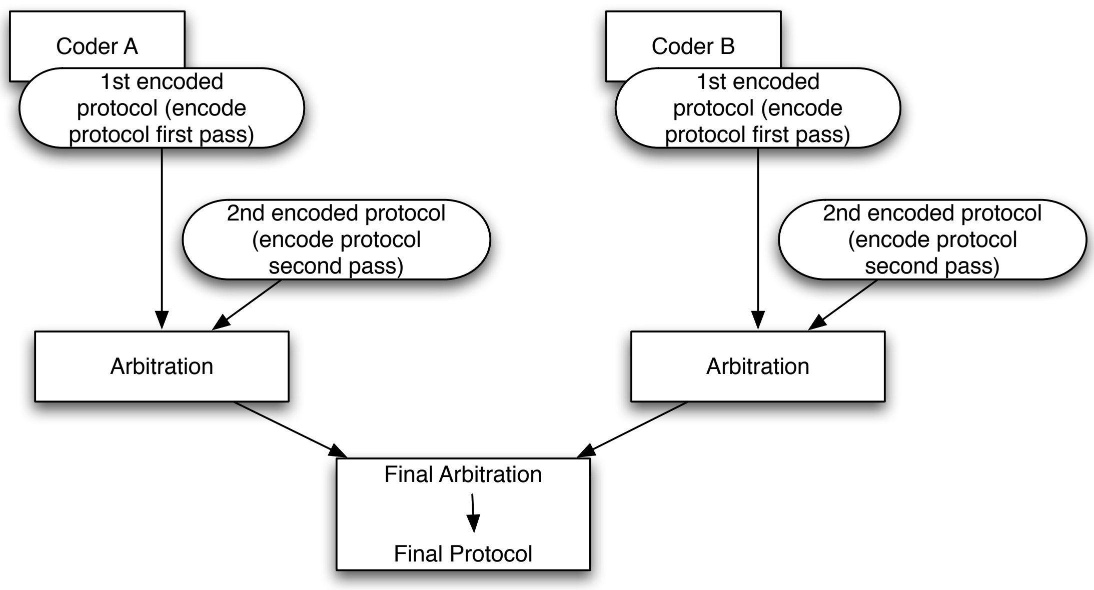


Figure 8. Delphi method of coding (Gero and McNeill 2006p. 5).

In this study, which differs from the Gero and McNeill (2006) study, there were two coders to perform four Delphi stages as illustrated in Figure 8. Throughout the process the coding scheme continued to be refined. However, Table 5 is a sample of the coding history using the Delphi Method.

Table 5

Delphi sample of coding history 125-Year meeting 1

Code	Utterance	1st	2nd	Recode	Final
3	The piece needs to deliver media of the following types: text, photos (so those are single photos as well as slide shows)	R	S	R	R
4	video and then also to be able to link to content that's housed outside of the timeline. / So if there is a link our something that's housed at the Minnesota Historical Society they want to link to they need the ability to link to those kinds of things	S	F	S	S
5	How about audio?	S	S	S	S
6	Go ahead there is also content in there like audio and they talked about having slide shows set to audio, think that we would do that in the form of video but we can talk about that as well.	S	S	S	S
7	Value proposition benefits we're looking at current student engagement and education for the historical parts of UST	F	Be	F	F
8	as well as Alumni engagement and past events that they have participated in or want to learn about	R	S	R	R
9	as well as donor engagement to continue the trends of the past and continue them on into the future.	R	Be	R	R
10	User interface decisions that came from that committee—there was some investigation of the competitive landscape and there was concern about how 125 years would be broken up because it is an odd number. More on that in a second and also because there is not very much stuff recorded for the early years so it was a little sparse there.	F	S	F	F
11	First problem of the design is that the first 15 years need to be lumped as a section of the timeline 'cause that's what they have enough events for' to not seem like an empty basket and the rest of the sections had enough to be divided into 10 year sections So fifteen years to get it to an even number and then round it out to 10.	R	Be	R	R
12	The client committed to never have more than 5 events in one year.	S	Be	S	S
13	It is most probably that there will be between 1 and 3 events per year.	S	S	S	S
14	That's what they are proposing and that's a challenge so we'll have to see if we can figure out a way to make 125 years be easily accessible. That's still out there.	S	S	S	Be
15	But if we do break it down they require that the first section be 15 years because there's like 5 events in the first 15 years	F	S	F	S
16	I think the deployment can be managed through Serena, but it doesn't need to be built as a set of document definitions or anything like that.	S	F	F	Bs

As part of the Delphi Method, the two encoded transcripts were compared for differences. According to Gero and McNeill (2006) two types of differences exist: 1) variation in segmentation, and 2) coding discrepancies where the coders attribute segments to different categories (demonstrated in Table 5 from the First Meeting on the 125-Year project).

Design protocols are usually interpreted or analyzed by using descriptive statistics for how designers spend their time on what they do. The null hypothesis is that the two sets are similar.

Table 6

Descriptive statistics from LINKOgrapher 125-Year timeline and Viewbook projects

Full Meeting	Segments	Links	Issue Activity Mean	Issue Activity STD	Link Distance Mean	Link Distance STD	Rate	Minutes
125 - 1	131	1259	62.6	34.4	30.6	26.0	2.62	50
125 - 2	289	928	149.2	66.6	68.6	72.5	4.98	58
125 - 3	276	1556	128.6	68.9	34.6	57.2	4.31	64
Viewbook- 1	163	3500	93.5	35.4	42.9	34.0	4.53	36
Viewbook- 2	116	2456	52.5	22.6	32.6	24.8	2.58	45
Viewbook- 3	134	3410	68.9	28.2	46.0	33.6	5.36	25

As illustrated in Table 6, there are 1,259 links among the 131 segments in the first meeting for the 125-Year project, so this session has a rate of 2.62. However, some segments have more links than others. Table 6 compares the distribution of the segments with the links for each of the project meetings and provides an example of how descriptive quantified data is used in Protocol Analysis. The results will be discussed in Chapter 5.

Markov Model

Markov analysis, also referred to as Markov chains, predict the probability of the transition events coded. The probability an event will occur and results are represented as a transition matrix as illustrated in Table 7. This method of analysis is one of the most frequently used to do sequential analysis and describes the sequence of events by the probability of one event leading to another.

Table 7

Sample data from 125-Year project meeting 1 for Syntactic and Semantic processes

Syntactic 1st Order Markov Model						
	R	F	Be	Bs	S	D
Requirement	0.53	0.07	0.07	0.00	0.20	0.13
Function	0.22	0.22	0.00	0.00	0.56	0.00
Expected Behavior	0.00	0.00	0.48	0.03	0.38	0.10
Structured Behavior	0.00	0.08	0.08	0.77	0.08	0.00
Structure	0.02	0.11	0.24	0.04	0.51	0.07
Description	0.21	0.00	0.11	0.00	0.11	0.58
Semantic 1st Order Markov Model						
	R	F	Be	Bs	S	D
Requirement	0.14	0.08	0.25	0.13	0.23	0.18
Function	0.02	0.09	0.34	0.32	0.22	0.00
Expected Behavior	0.04	0.00	0.46	0.10	0.34	0.06
Structured Behavior	0.00	0.06	0.02	0.92	0.00	0.00
Structure	0.00	0.07	0.26	0.14	0.53	0.00
Description	0.38	0.00	0.06	0.00	0.00	0.57

A Markov chain is a discrete time state determined both by the process's predictable actions and by a random element. There are in the design process many possibilities the process might go to with the large number of combinations of transition states, but some paths may be more probable and others less so, such that the next state solely depends on the present state. The numbers in Table 7 represent the probability of an event; for example, in the second row the probability of an F state being followed by another F state (F-F) is 0.22. The probability of an F state being followed by a Be state (F-Be) and S state (F-S) is 0.34 and 0.22 respectively.

The two design projects in this study were similar to the design episode analysis performed at Key Centre of Design Computing of Sydney by Gero and McNeill (2006) in which the designer was given a creative brief upon which to base the project rather than asked to work on something familiar. The difference in this study was that the research used real world projects that were worked on and completed for clients.

The coding scheme used as analysis demonstrated the potential of obtaining highly articulate analyses to answer the questions: does behavior structure coding of the designers on the project influence an outcome in the design process and can the data gathered from the coding process supply subsequent information to improve the design process? The results were explored graphically and allowed a comparison between design sessions and projects. Results shown illustrated the utility of this approach in gaining some insight into how designer's design, the contribution that experience plays in design, and the similarities and differences in designers' approaches. Gero and McNeill (2006) posit that these tools still require further development and a large number of design sessions within and across disciplines should be part of future work.

Description of Steps

The following sections describe each of the four phases that structured the steps this project followed. Each step used protocol analysis as described earlier to collect information appropriate to the steps in the process. The same protocol was followed for each step.

Step 1–Creative Design Brief Meeting Protocol Analysis

This study used three critical meetings that are norms for designers and developers. At the meetings, team members negotiated a project, the concept, approach, logic and actual deliverables. This meeting was the first of three face-to-face meetings used to provide the data obtained through protocol analysis of the design and development team interactions and required at least two external researcher observers to observe and record the process.

There were some general categories that could be incorporated into the observations, regardless of the research topic, and questions that were used for this study process. For example, categories to observe in addition to the overall design process, decision making and collaboration included: verbal behavior and interactions, physical behavior and gestures, personal space, human traffic and individuals who stand out. The external research observers documented and categorized the design team's process using the qualitative methods of video, journaling, direct observation and the collaborative technology tool itself. In addition, the video and observation was reviewed with the help of an outside person, and the protocol analysis data was triangulated for arbitrated results.

The creative design brief meeting was to discuss the Creative Brief (Appendix B) and the overall approach to the project. The Creative Brief document submitted by the client formed the structure of the meeting and provided a brief description of the project. The brief also outlined the objectives, audience, and assumptions for the project. The Creative Brief typically provides much of the background and research data collected based on general audience surveys, competitive analysis, stakeholder interviews, web analytics, and internal and external feedback from polling and surveying on the web site for feedback on the project. Studies of design problems suggest that gathering thorough client requirements is a critical step for the participants and is often not given adequate attention.

Step 2–Collaboration on Design Project: Outside the Formal Group Design Meeting using Adobe Connect Professional, iChat and Protocol Analysis

Adobe Acrobat Connect Professional is a virtual collaboration technology that recorded the collaboration process and captured the interaction and collaboration as the process evolved. The technology was intended to aid in documenting and acting as a repository for the collaborative process. The team preferred iChat to Connect and predominantly commented on and shared files back and forth outside team meetings; unfortunately these interactions were not recorded or captured as planned. Future research to analyze the artifacts produced during this process is a design process opportunity.

Projects are no longer limited to local, real-time interactions, as in the case of design meetings and design reviews. Rather, they can now be undertaken in an online environment, with the assurance of encapsulating more information, affording more opportunity to reflect, and continuing collaboration for a longer time period more research on the use and practice is needed in this area.

iChat was the tool used in the process to seek approval on decisions and actions outside the construct of a formal meeting venue. The assumption here was that design teams employ a variety of technologies, artifacts and communication methods to move their product through a process that results in the final product. In this study, iChat provided a mechanism for collecting feedback on the progress of the process between designers and developers. For example, much review of initial mock-ups was done via email, without an understanding of client influence or reaction. In addition, feedback and initial reactions to design decisions and artifacts was often done using instant message (IM) and iChat. The intent was to document the process and assist in exploring opportunities to experiment with the design delivery and receipt and at the same time employ technology currently in practice. Although it was confirmed that some outside collaboration with iChat and IM occurred, none of the exchanges were documented or recorded.

A great deal of collaboration occurred between and outside of face-to-face meetings: personal observations, verbal and electronic discussion, presentation material (e.g., Microsoft Powerpoint, shared desktop files of Adobe Photoshop or Illustrator and Microsoft Visio).

Step 3–Post Design Meeting Protocol Analysis

This was the second face-to-face meeting of the design process. The outcome of the Post Design Meeting was to select one solution or treatment to the solution that would be presented to the client. The meeting did not preclude the client from asking for an alternative and, as a typical practice in the process, a second choice was available to show the client another approach and perspective. The team's presentation included

- Proposed design direction(s);
- Recommended or preferred design direction;
- General idea or rationale behind proposed solution concept(s);
- Some dramatization of concept(s), including sketches; and
- Report on any further information believed to be necessary to proceed with this project.

After the team arrived at alternative design directions in the Post Design Meeting, the design team participants presented their ideas and direction to the client. The presentation involved conceptual representation of the interface and supporting information and research that supported the direction and selection of the suggested artifact.

Step 4–Client Usability Meeting Protocol Analysis

Mapping users' intended goals and then testing to ensure the target audience can easily achieve them is a core part of client usability testing. The first task in this project was to determine who was the intended or potential user. Once the interaction designers figured that out, they created descriptions of typical users. These characters, known as personas, represented the actual users of the system. Persona descriptions provided details about age, gender, education, seniority, and learning style.

The designers had to decide on the sorts of things each target user wanted to do. Designers brainstormed with the client to build a list of possible goals for their users, based on research and experience, built scenarios around those goals, then, constructed a setting to observe if real users matched to the potential user's expertise in order to achieve the goal. The usability meeting consisted of walking the client through the process, but the actual observation of how the users used the system was not captured.

The protocol analysis process was followed to examine decisions made by the client discussion and was compared to the analysis done during the other design phases. The comparison looked for places that were complex in the process or required extra discussion. A compare and contrast analysis was then done to identify needed changes to the final outcome. Client's feedback from the session was incorporated into the final designs.

Subjects, Coding, Researcher and Observer Roles and Physical Setting

This section provides information about my role as researcher and the external research observer role not covered earlier. Also included in this section is a simple narrative of the physical meeting space setting that was video taped, the working area, and the tools participants used during the project.

Selection of Subjects, Outside Protocol Analysis Coders

Two external researchers were utilized to observe and code the designers and developers in their actual working environment as they engaged in the real design problems that were used for this study. They made sure the recording worked and coded each of the meetings with the FBS coding scheme. Multiple revisions were required based on feedback from John Gero to code the data accurately, and this researcher was the final coder to complete the arbitrated versions of the coding.

In total, nine team members participated in this study—four designers and five developers. The team members were University of St. Thomas employees who participated as volunteers. They were not compensated in any way nor was course credit received for their participation. The research protocol was submitted and approved by the University of Minnesota and University of St. Thomas IRB review committees.

The team members have varied but extensive professional experience in their fields and have worked together on similar or related projects. Although they were not categorized as experts, they were all beyond the novice experience level.

More descriptive information on the subjects is provided in Appendix A and C. Appendix A describes their background and years of experience and Appendix C describes their required skills and job functions.

Before the observation began, the subjects were assured that their actions and interactions during the study were confidential and that none of their real names would be included when the results of the research were made public. The statement of informed consent that all subjects were required to read and sign is provided in Appendix D.

Researchers Roles

External research observers were responsible for:

- Beginning each design session meeting with the process instructions for observing and recording the sessions;
- Answering any procedural questions from the participants;
- Ensuring that the video and tape equipment continued to function;
- Recording any activity that video could not capture, writing field notes that recorded the activity; and
- Collecting all notes and sketches generated by the design team and converting them to digital format with either flatbed scanner or digital camera.

My role was limited to analyzing the data collected by the outside research observers and reworking the coding towards arbitration and preparation for analysis. I was not part of the design space and discussion. However, because the study used actual projects, I received the presentation of the final, suggested, design directions that were taken to the client after the Post Design Meeting.

Physical Setting

The three meeting sessions observed, coded and analyzed for this study were held in a workgroup meeting area that was wired for sound and video recording equipment. The room was arranged with a 62 inch TV panel for desktop projection on the wall, lined with whiteboards and a large table in the middle of the room with chairs around it, as illustrated in Figure 9. Most of the documents and referenced examples came from the computer projection and video recording captured the interactions during the project meetings.

Figure 9. Session room configuration.

The subjects had access to sketch pads, post-its, pens, whiteboards and software (Adobe Illustrator, Photoshop, Flash and Dreamweaver, Microsoft Powerpoint, etc.) to create the desired artifacts to support their overall approach to the concepts and how they chose to present the concept to the group throughout the design/development process.

Summary

The external researchers observed and recorded three meetings for each of the two projects used for this research and coded them using protocol analysis. Specifically, these meetings were: the creative design brief meeting, the post design meeting and the client usability meeting. All six sessions were recorded, transcribed, FBS schema was coded and the Delphi method was used to arbitrate the final coding. This researcher performed the final coding and the linkograph coding that was imported into LINKOgrapher 1.0 for analysis.

Chapter 4

Analysis of Data

This study presents results of a case study of interaction design professionals collaborating on two consecutive and similar design problems in a workplace setting. Practicing designers' and developers' cognitive processes were evaluated as they worked as part of a project team designing and developing two similar products for their workplace with two different goals and clients using a task-independent approach to verbal protocol analysis based on the (FBS) function-behavior-structure ontology. The data from two similar real-time projects were analyzed. Much of the protocol research mentioned earlier compares at least two sessions, projects, teams or individuals to compare results. Although the projects were not conducted simultaneously, they were consecutive and comparable in the clients' desired outcomes. The occurrences of design issues, syntactic and semantic design processes from each of the six design sessions are analyzed and compared in order to identify differences in interface designers' design behaviors.

The findings provide an opportunity to investigate and understand how interface design professionals collaborate and make decisions regarding their design artifacts. The 125-Year anniversary project started before the Viewbook was underway. The results indicate that changes in design cognition occur over time as expertise and knowledge is gained by observing other design patterns and experience with design problems. The change manifests itself in an increase in focus on the purposes of designs being produced, which is often a precursor to the production of higher quality designs, and an increase in entropy in the design processes associated with the balance of the introduction of new or consolidating ideas. Entropy, in this case, measuring novel ideas verses predictability in the opportunities for idea development of a team. It also reflects the opportunistic contributions of individual participants in the increase or decline of ideas.

Using qualitative and quantitative data collected from the FBS ontology process is a combination of observation and results based on implementing and analyzing the process. The qualitative results are described in the basic comparison and then mixed in with the quantitative methodology of the distributions in the FBS ontology process analysis, the results of which are organized in the order of the procedures as they are executed: 1) issues, 2) syntactic, and 3) semantic distributions.

The Markov model provides probabilities for trends between transitions and the pattern of turn taking. A random process in probability theory, the Markov chain is the simplest process that models the states of a system, in this case FBS, with a random variable that goes through transitions from one state to another (changes through time), between a finite or countable number of possible states. The probability of the next state depends only on the current state and not on the sequence of events that preceded it. Markov chains have many applications as statistical models of real-world processes and is used hear to analyze trends in the FBS process. After the segmenting, coding and linkograph are completed, the LINKOgrapher software can generate the Markov results from the sessions (see Markov section for the results of the six sessions).

Entropy exposes the opportunities for idea development. The sessions with a greater amount of open participation provide more opportunities for idea development while fixation manifests as an early or hasty commitment to a particular design solution. The method for using entropy is to segment, use FBS to code, generate the linkograph and produce its dynamic entropy with LINKographer software. Once the linkograph is produced LINKographer produces graphs to represent peaks and valleys in the forelinks and backlinks relating to the topics discussed in the sessions. The sharp drops in entropy represent fixation and measure the extent of the entropy reduction to measure the extent of the fixation (see the entropy section in this Chapter for graphs of the six sessions Figures 21 through 26).

Organization of Data Analysis

In both projects the team members remained constant with nine male participants whose professional work experience in interface design projects ranged from 2 to 17 years. Their background education and years working in the profession are described in Appendix A. A total of six sessions for the two projects produced qualitative and quantitative data providing analysis of the interaction and collaboration of the design process. General overviews of the session intention and dominance of the protocols that occurred during the sessions are discussed.

A number of research projects have utilized the FBS ontology. The approaches developed to analyze information collected from protocol analysis and their different measurement methods are applied in this research. This case study captured general statistic, code and problem structure indices, percentage issue, syntactic, and semantic distribution process, Markov model and entropy measure data for the sessions. LINKOgrapher carries out these measurements and generates the responding models for each of them.

The research questions that frame this research project form the analysis collected with this ontology and support the versatility of this method for design research in general.

Research Questions and Associated Hypotheses

The FBS ontology is a standard method of measuring the design process and can be applied to measures that derive analysis of issues in the process, transitions within the process and idea generation as an important creative design measure. Protocol analysis has been established as a dominant method to be used to describe the cognitive and development process of designing. This case study and others demonstrate that FBS ontology and protocol analysis is a promising method for describing interface design work. Although not yet used for user experience (UX) design, protocol analysis is the most promising method for clarifying design-thinking behavior and providing a framework to describe the designer's role in web development and functional specification.

The two project case studies demonstrate the kinds of information that can be abstracted from linkographs regardless of the type of designer and showcases the versatility of the FBS ontology. The qualitative data together with the linkograph provide validation for much of the quantitative data collected.

All the data analysis available from these two projects, six sessions total, is not presented here. A number of studies conducted by Gero also compare the first half with the second half of a session because the sessions varied in length that data were not used in this study. Analysing of the roles from each of the segments and evaluating the first and second half of the sessions can provide additional information about the verbal reports of thought sequences design plays in interface design projects. In addition, only the first order Markov data is presented, but the Syntactic 2^{nd} Order Markov Model was omitted and can provide another layer of analysis at a later time. Previous research followed individuals throughout the sessions to examine role and influence in the projects decisions; during the coding process the names were removed. However, going back to the code and adding back the individuals that participated provides another opportunity for future study on the roles and partnerships formed by the different individuals.

The two project case studies demonstrate, but do not exhaust, the kinds of information that can be abstracted from linkographs and the FBS ontology. Linkography is a technique used in protocol analysis to study the structure of reasoning of designers. It was used to measure productivity of designers, study creative process, and examine the strength quality of ideas. A linkograph is constructed by linking related segments; links are established by discerning, through common sense, whether a move is connected to the previous moves. Data from the linkograph produced issue, syntactic and semantic distribution, First order Markov and entropy to show learning and collaboration over time and describe distinctions in multidisciplinary design teams' approaches to the design process in their problem-solving and task-setting processes. The linkograph provides a process signature for the design session. Consequently, the data gathered can provide subsequent information to improve the design process as well as applying this method to future similar projects to help establish generalizations instead of case based assumptions.

Analysis of Data Overview

The FBS coding of the transcripts from the two project case studies provided data to use different methods of analysis. The analysis is both qualitative and quantitative. The linkograph in protocol studies provides methods for acquiring qualitative and quantitative analysis. The linkograph analysis produced results, which describe the cognitive efforts of the participants in percentage or count total on different classes of functions in the process. This provided the basis for basic design process analysis and captured basic design activities. Generally, design models are iterative processing analysis, synthesis, and evaluation until a satisfactory design is produced. Therefore, another measure representing the dynamic variables are the eight design process descriptions. They model the series of progressions among the FBS variables, as illustrated in Figure 7, and provided further analysis of the process. The FBS ontology expands the design state beyond analysis, synthesis and evaluation to include three types of reformulations that aim to capture the innovation and creative aspects of designing. The FBS process standardizes the design method and results from these different methods provide abstractions and descriptions for analysis. Qualitative and quantitative observations of the protocol sessions provide the framework of the design process and outline the structure for the results presented in this study.

Qualitative Analysis of the Sessions

The three sessions of each project were conducted at approximately the same phase in the project development process. For example, the first meetings of each project were to review the project goals with the project team, as described by the client in the Creative Brief in Appendix B. The second meetings were to finalize concepts based on decisions about function and behavior of the design solution before presenting it to clients, while the third meetings in the series were to meet with the client in a usability and initial feedback format before final release and launch of the design project. Basic comparisons discuss the qualitative analysis from the sessions, between comparable meetings and across projects.

Basic Comparisons for First Sessions

In the first meeting of both 125-Year timeline and Viewbook, the project teams focused on the functional and conceptual (requirements) aspects of the design and some discussion of the (behavior) goals based on the Creative Brief. In the beginning of the sessions the designers frequently referred to existing examples of web projects they had seen or recalled to be attempting something similar to the desired outcome. In discussing approaches to designing the designers' referred to design patterns, general reusable solution to a commonly occurring problem, for their suggested solutions. The designers exercised case-based design reasoning by analyzing examples and methods of treating information to guide application decision-making and unobtrusively learn new patterns during the decision making process.

The initial meetings for both projects also included a focus of the discussion on the intended audience. The audience discussion was twofold, the audience that needs to input the content and maintain the relevancy of it and the intended audience of the content and message. Although the audiences were different the discussion considered the types of content, formats of delivery and limits on the amount of elements of content to preserve design structure integrity. For example, the issues of limiting the number of videos or images that can be displayed at one time in the timeline and limiting the number of categories for the Viewbook to fit and display symmetrical by column were debated.

Project Requirements In Common

Both projects required a structure to deliver a variety of content and information and a means for inputting the content. The project team discussed the importance of content uniformity and the difficulty of creating a system that would not require content manipulation prior to adding the piece of content to the system if the insertion were to be performed by the client. The team was aware of content management system functionality, but both projects were unique and unstructured enough to not fit the confines of structured content, ruling out the UST web content management system as a solution. Therefore, both projects required discussion and decisions around creating a system or design framework to accommodate an approach to structured and unstructured content.

Project Metaphors

Both projects discussed an appropriate metaphor to influence and assist the audience in interacting with the content being delivered. The 125-Year project leveraged the metaphor of a slide or video projector to demonstrate the movement through the content on the timeline and light window box as a mouse-hover queue to convey clickable sub-navigation or object enlargement.

Figure 10. 125-Year slideshow and timeline view.

The projector acts as both a slide show and card sort for moving through the decades and expanses of content. The viewer activates a hover state illuminating the current element to enlarge or view the current object. The approach to the Viewbook incorporated smartphone functionality with more of a slider effect for moving from one screen or section to the next.

Figure 11. Viewbook smartphone view.

Although this is a less obvious metaphor in comparison, the intended audience is familiar with navigating image and video content on their phones and the web without much education or assistance. The metaphor selection discussion also included segments focusing around ways the content was to be browsed, searched, and skipped to accommodate a non-linear audience.

Basic Comparisons for Second Sessions

For both projects the second recorded sessions can be encapsulated in four core areas of emphasis: metaphor, look and feel, navigation and organization of content. Two additional articulated needs unique to the 125-Year project were: the requirement to accommodate pre-existing content, historical images and videos, and integrate them in a way that fits with the style of the interface; and load time for individual elements and overall interaction within the application.

Typically, the content originates from the client; however, organization and information architecture are encompassed in the structural discussions and incorporated into the user experience decisions. The projects in addition to multimedia elements were designed for structured and unstructured content to be navigated linearly and non-linearly. Although the approaches were different based on audience and design goals the discussions pertaining to these decisions occurred during these design session.

At this point in both projects, concepts had been created and discussion around finalizing color, fonts, background, style and structure pervaded the sessions. The designers operated in a design review mode evaluating the concepts and approaches with collaborative agreement on suggestions and changes prior to client review. The sessions culminated with approval of design style and treatment of structural elements in preparation for client review and approval. Although unanswered questions remained for the client at the end of this session for both projects, the last meeting was with the client for feedback on design, usability and outlying requirements not yet captured.

Usability and Comparisons of the Third Sessions

The University of St. Thomas' approach to interface design is iterative and incorporates client feedback at various points in the process. Although client requirements were not part of the data collected, review and usability were solicited and captured as part of the case studies. The third meeting of the projects included key stakeholders representing the clients for which the projects were produced. The discussions in these sessions were to gage an initial reaction of: the designed concept, usability of the function and navigation, categorization of the content and limitation of the systems expected behavior based on decisions to incorporate content.

Both meetings introduced design concepts to clients along with a brief explanation of the approach and functional decisions to arrive at the structure and behavior of the product. The clients affirmed the overall concepts, and discussion moved quickly to content details and specific treatment of content types. The organization and categorization was affirmed and discussed to verify exceptions and augmentations were considered as the content expands over time. In addition to the flexibility, discussion for adding new content, limitations and structural guidelines were discussed to assist and educate the client on design decisions that were made to create the design, and in some instances constrain the content. For example, 125-Year timeline was limited to no more than three elements per year by decade and for the Viewbook the client was limited to the number of views and videos to suggest examples instead of inventorying all dorm rooms.

A goal of the third session was to assess the client's responses and comfort with the function of the metaphor and the navigation choices for the intended audience. Open ended questions where used to evaluative the intuitiveness of the navigation and the design patterns leveraged to present ways of finding and moving through the content and information. The project team solicited feedback as the concepts were demonstrated for guidance in any improvements or foreseeable problems in the approaches taken. In general the meetings were solution oriented and approval focused.

Each project included a specific discussion with the stakeholders regarding marketing and promotion of the final product after it was released. For the 125-Year, concern was raised for placement and way finding after the initial launch promotion was completed. The shelf life of the product after the promotion, and concern was voiced and discussed about finding the site after marketing efforts had been replaced by other priorities over time. The marketing discussion for the Viewbook was related to incorporating viral elements of social media and current student campus information such as TommieMedia.com and KUST radio for engaging and retaining the intended audience. The meetings ended in general approval of the deliverables and encouragement made for finalization as the next phase in the process.

Comparison Across Projects and Quantitative Analysis

The segmented protocols ranged for 116 to 289 segments. The word counts varied from 3,645 to 13,592, the second meeting of the 125-Year timeline being the largest. Table 8 shows each of the meetings with their links, segments, total time transcribed and word count. Although the projects were similar in client need, the discussion and time spent was shorter for Viewbook than for the 125-Year timeline because they had learned from their evaluation and analysis discussions for the 125-Year timeline.

Table 8

FBS Projects Overview

Full Meeting	Links	Segments	Rate	Minutes per	Word Count
Meeting 125 - 1	1259	131	2.62	50 minutes	4,456
Meeting 125 - 2	928	289	4.98	58 minutes	13,592
Meeting 125 - 3	1556	276	4.31	64 minutes	6,663
Meeting Viewbook - 1	3500	163	4.53	36 minutes	3,645
Meeting Viewbook - 2	2456	116	2.58	45 minutes	4,910
Meeting Viewbook - 3	3410	134	5.36	25 minutes	3,899

The lower number of links for the 125-Year project with the larger number of segments in comparison to Viewbook suggests that there was more diversity of ideas. The higher number of links or the more fully linked linkograph for the Viewbook project suggest the team fixated, had lower diversification of ideas and converged more quickly. The second meeting of the 125-Year project word count was significantly larger than the other meetings. The high word count with the low number of links suggests a large diversity of ideas. This along with the meeting containing the largest number of segments indicates that discussion was still strongly focused on the problem instead of the solution (see problem structure index Table 20 for additional results on problem over solution measurement analysis). Although the rate of 4.98 segments per minute for the second 125-Year meeting was fairly average for this project team of nine suggests that the speed of design activity was relatively higher than the first session, but comparable to other meeting sessions with the exception of the second meeting of the Viewbook project. By comparison the second Viewbook meeting had a high number of links with 2.58 rate of segments per minute denoting the team did not as quickly process design activities or generate new or diverse ideas in this session. In general the Viewbook project sessions had smaller numbers of segments with much higher numbers of links as compared to the 125-Year project suggesting the team converged on a design direction and did not generate much new or diverse ideas once decided. Although the projects were similar the coding results from the six sessions varied based on different distributions and analyses of the process.

Design Issues Distribution

The designing process in terms of the three fundamental non-overlapping concepts which are (F) function, (B) behavior, and (S) structure, along with two external classes of concepts: (D) design description and (R) requirements are the issues to change a set of functions into design descriptions. Figure 12 demonstrates similarities across projects and sessions. The utterance segments that did not relate to design issues were coded as “O” and omitted from further analysis.

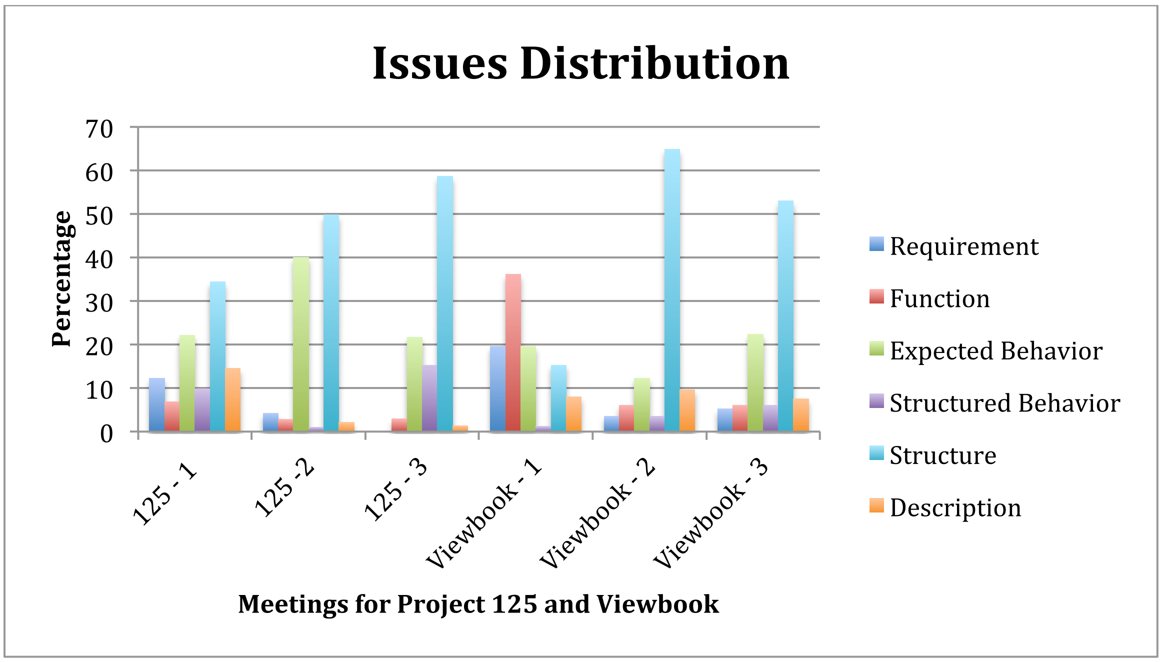


Figure 12 The distribution of FBS codes for the projects.

The team comprised of developers and designers spent most of their effort on (Be) expected behavior of the applications averaging 23% per session and the (S) structure averaging 46% per session of their discussion throughout all the sessions as the dominant concepts emphasized. As was mentioned in the qualitative discussion, this could be attributed to the predominant discussions of way finding, navigating the content, the metaphor and design elements of the presentation and user experience of the two projects. The percentages for design issues are displayed in Table 9 for the two projects.

Table 9

Issue Distribution Percentages

FBS Percentage	125 - 1	125 - 2	125 - 3	Viewbook - 1	Viewbook - 2	Viewbook - 3
Requirement	12.2	4.2	0.0	19.6	3.5	5.2
Function	6.9	2.8	2.9	36.2	6.1	6.0
Expected Behavior	22.1	40.1	21.7	19.6	12.3	22.4
Structured Behavior	9.9	1.0	15.2	1.2	3.5	6.0
Structure	34.4	49.8	58.7	15.3	64.9	53.0
Description	14.5	2.1	1.4	8.0	9.6	7.5

The (R) requirements do not reflect comparable percentages across the project's sesssions that is to be expected as their order in the process should be at the beginning which is consistent and comparable in both projects. Functional discussions are also demonstratable early in the process, although much higher in the Viewbook project overall with 36.2 percent occurring in the first session. A possible explaination is that more examples existed and were discussed in the 125-Year than the Viewbook project and more clarification was required about what the function of the Viewbook was needed to inititate the design process. The emphasis of the structure discussion was dominant throughout all the sessions. It was a larger percentage in the second and third sessions: the second session because they described the design directions taken in both project cases and the third session because they presented the design direction and decisions to the client. The projects were similar in process and time spent on issues, however the (Be) expected behavior and (F) discussions delivered different results in the design projects delivered. The 125-Year project was overall more complex and required more disparate ideas to incorporate into designing the resulting system for editing and delivering the artifacts it contained. The Viewbook was a more straightforward product once the (R) requirements (F) function and (Be) expected behavior where discussed and clarified.

Although the process and time spent is similar, there are differences between the project sessions. The code count results for issue distribution are compared to the percentages for each issue of the six sessions and are presented in Table 10. The 125-Year project generated more data resulting in higher code counts, but some additional session comparisons can be drawn from percentage and code count.

Table 10

Issues Distribution Percentage Compare with Code Count All Sessions

	Percent	Count	Percent	Count
Issues	125 - 1	125 - 1	Viewbook - 1	Viewbook - 1
Requirement	12.2	16	19.6	32
Function	6.9	9	36.2	59
Expected Behavior	22.1	29	19.6	32
Structured Behavior	9.9	13	1.2	2
Structure	34.4	45	15.3	25
Description	14.5	19	8.0	13

	Percent	Count	Percent	Count
Issues	125 - 2	125 -2	Viewbook - 2	Viewbook - 2
Requirement	4.2	12	3.5	4
Function	2.8	8	6.1	7
Expected Behavior	40.1	116	12.3	14
Structured Behavior	1.0	3	3.5	4
Structure	49.8	144	64.9	74
Description	2.1	6	9.6	11

	Percent	Count	Percent	Count
Issues	125 - 3	125 - 3	Viewbook - 3	Viewbook - 3
Requirement	0	0	5.2	7
Function	2.9	5	6	8
Expected Behavior	21.7	76	22.4	30
Structured Behavior	15.2	34	6	8
Structure	58.7	156	53	71
Description	1.4	5	7.5	10

In a comparison between the 125-Year and the Viewbook for session one, the code count of

(R) requirements for the Viewbook was (32) two times more than the 125-Year (Table 10).

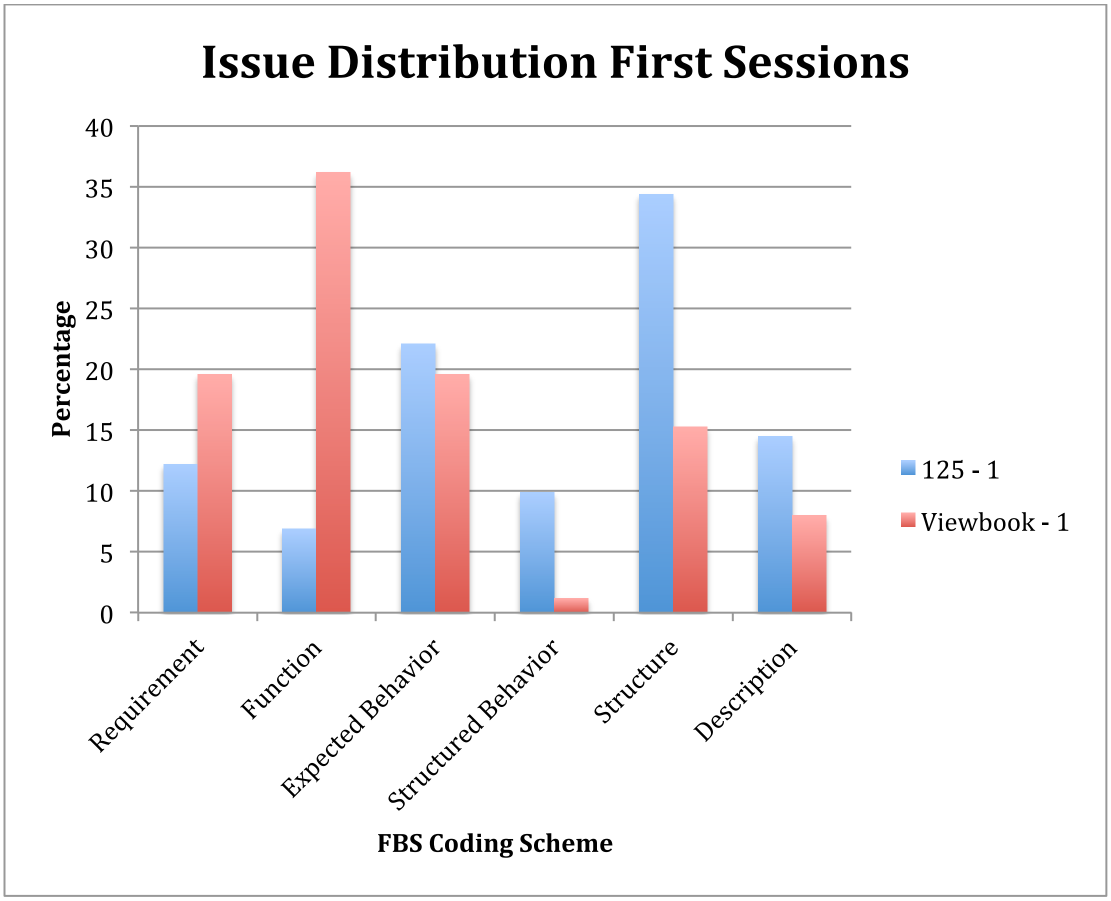


Figure 13 The issue distribution of FBS for meeting 1 both projects (Creative Brief).

In addition the code count for (F) function was (59) six times the count than for the Viewbook, another indication that the purpose and utility of the Viewbook was less clearly understood. This is listed in Table 10 and visually demonstrated in Figure 13. The first session's distribution of issues was more similar between the projects while the second session was more divergent across issues.

In the second session the 125-Year compared to Viewbook was almost four times (40.1 percent or 116 code count segments over 12.3 percent or 14 code count segments) more effort and emphasis in percentage and code count was (Be) expected behavior as demonstrated in Table 10 and Figure 14. Even though structure was a higher percentage of issues in both projects, the 125-Year project was twice as much in session two over Viewbook.

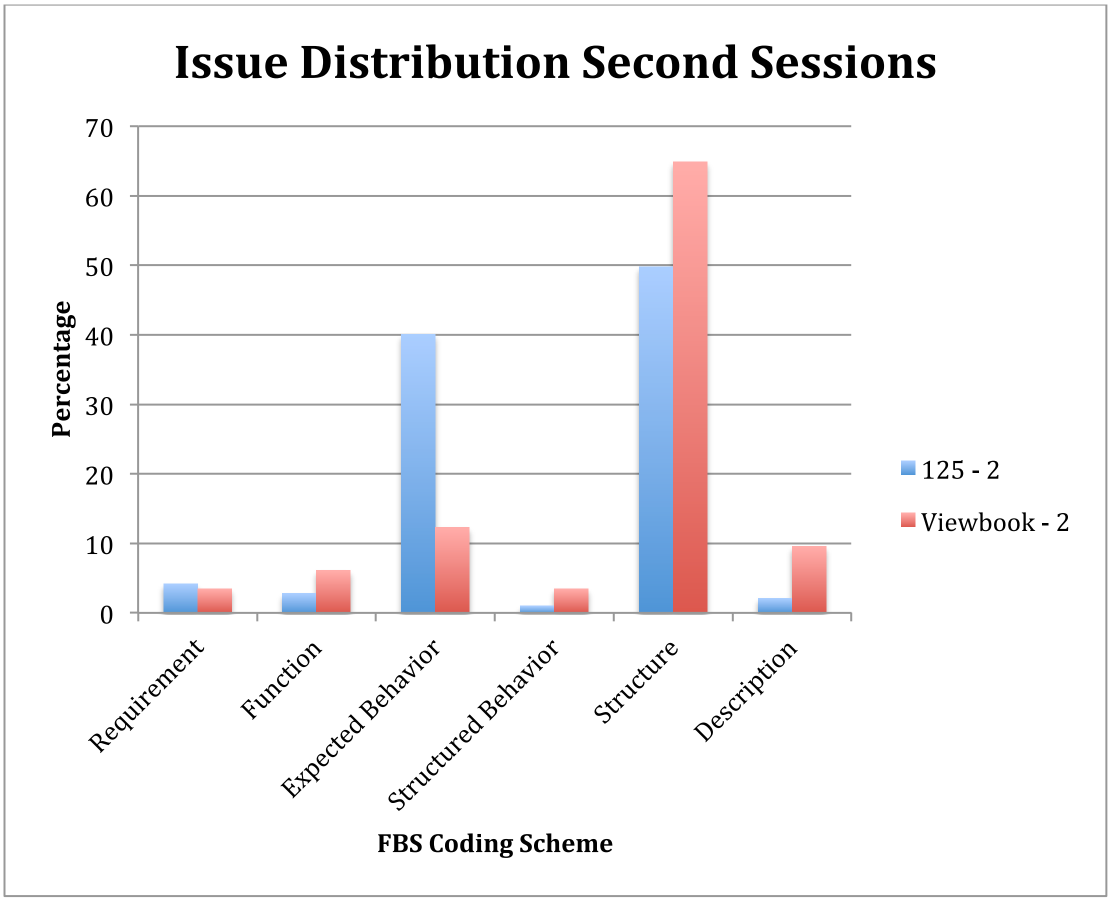


Figure 14 The issue distribution of FBS for meeting 2 both projects (Post Design).

The design of the interface and navigation for project 125-Year was complex and unique in style and visual elements because it was separate and did not conform to established university branding elements; this is reason for more time spent on (Be) expected behavior and (S) structure. By comparison, there are more issue differences in sessions one and two than in session three for the two projects.

The session with the client present or third sessions were more similar in the time spent on the respective issues. Figure 15 illustrates the issues normalized by using the percentages to represent their parallels.

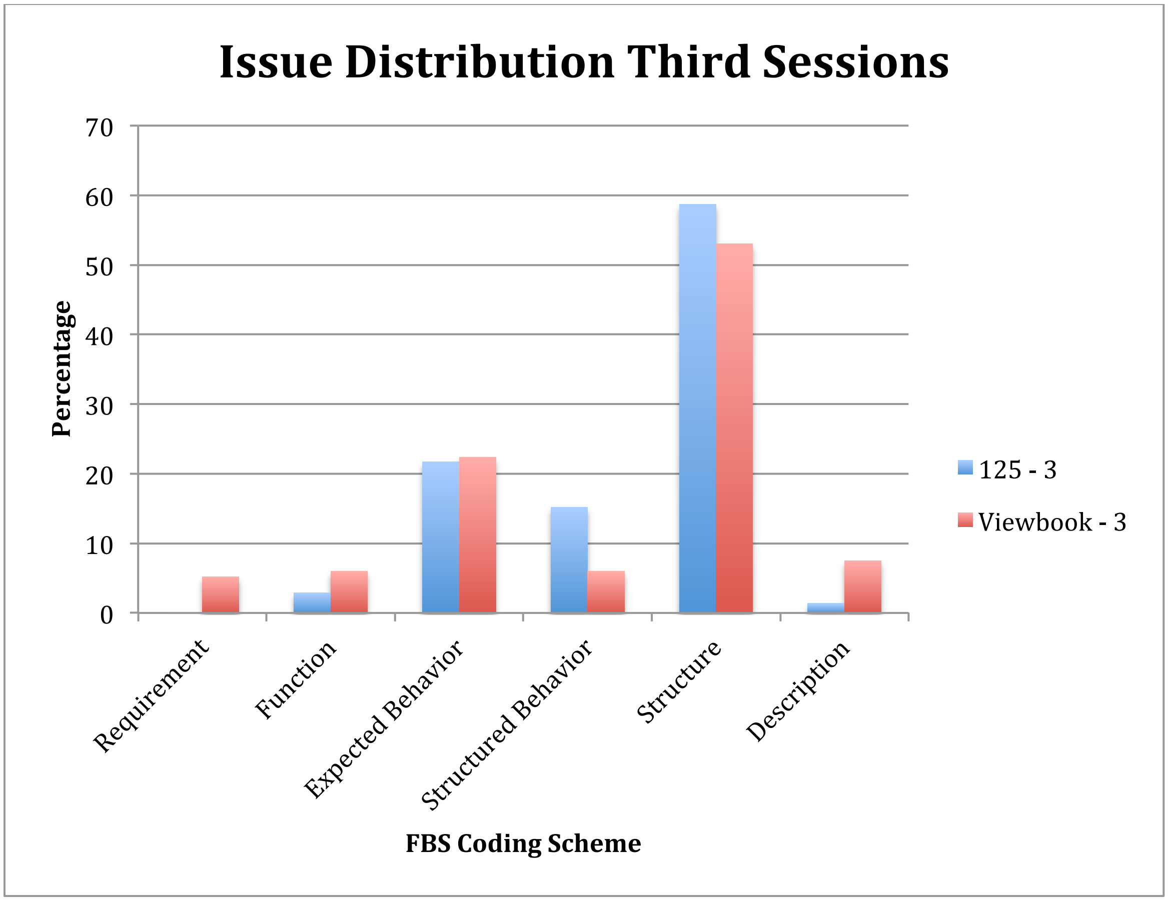


Figure 15 The issue distribution of FBS for meeting 3 both projects (Usability).

The one difference to note for session three is (Bs) structured behavior is more than twice as much in the 125-Year project as in the Viewbook. The resulting design decisions for (F) function and (Be) expected behavior delivered to the client suggests the team's process required more explaining to the client why the applications (Bs) structured behavior performed as expected.

The design issues provide information about the individual issues and their importance on that particular design problem. The method of coding allows for only one design issue for each segment and eliminates any overlapping codes or multi-code segments in the coded protocol to capture the essence of design activities. However, the aim of designing is to develop and transform functions into structures and finally elements or artifacts in this case into interface projects. The design processes, in addition to capturing activities, examines the transitional events between code pairs already described in Chapter 3 (Figure 7). Syntactic and semantic issue distributions in the 125-Year and the Viewbook projects allow for analysis of the issues in their transitional processes and are thought, by researchers using FBS, to more accurately model the actual creative and iterative design process.

Syntactic Issue Distribution

Design processes are defined as transitional processes between code pairs, and in syntactic mode, related codes are described by their position in the sequence. The neighbor codes (the code before and the code after it in the sessions) are treated as being related to each other. The conceptual connections of the codes are derived from the linkograph of the coded design protocol.

The transitional processes are formulation, syntheses, analysis, evaluation, documentation and reformulation: formulation transforms functions into (Be) expected behavior, synthesis fulfills the (Be) expected behavior of a proposed (S) structure, analysis of the structure produces (Bs) structured behavior and behavior derived from (S) structure, (D) documentation is the product of design description, and the three types of formulation are from (S) structure, (Be) expected behavior and (F) function. Figure 16 illustrates the syntactic distribution of the six sessions by percentage.

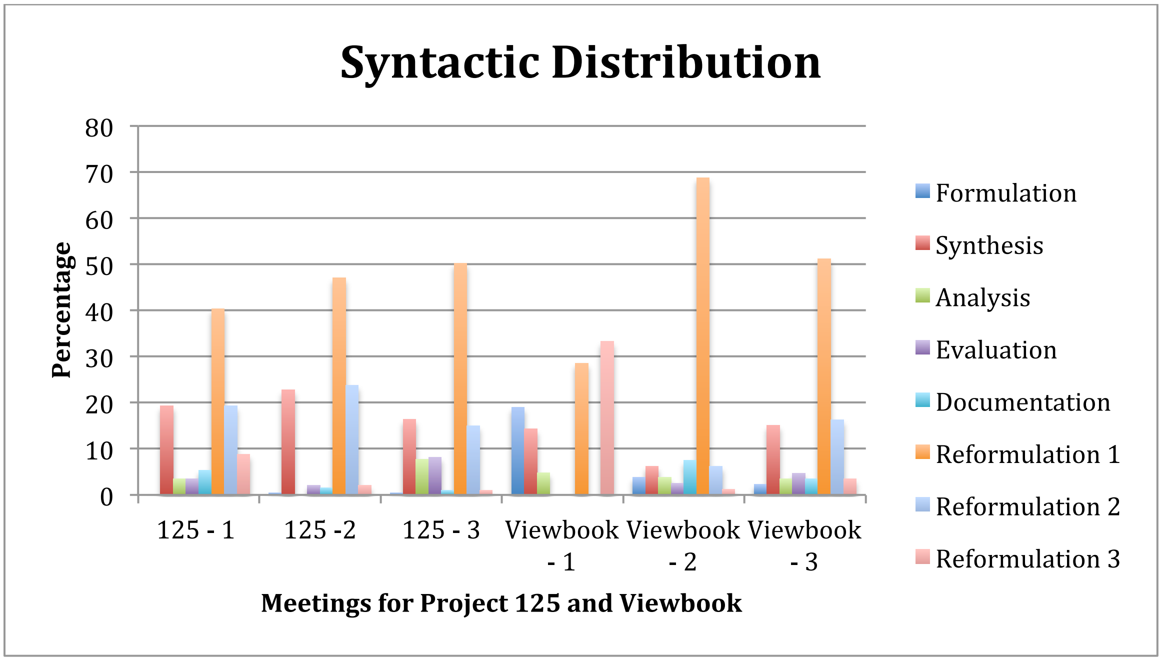


Figure 16 The syntactic distribution of FBS for all six sessions.

Also, Figure 16 compares the distribution of processes but not the quantity of those processes. In FBS protocol studies, analyzing and synthesizing activities refer to a design thinking cycle. The transitional process most performed overall was Reformulation I or (S) structure to (S) structure, which is the process of changing the space of possible designs by changing the structure. In general for both projects, the team worked more independently to create and make objects, spent less time on generating and developing ideas. This was reflected in the derived processes, which had a high percentage of structure reformulations, graphed in distinguished peaks in Figure 16.

Typically analysis occurs in the process when the focus is on the problem through analyzing, clarifying, and identifying it, while synthesis take place in the solution space: proposing and analyzing the design outcome. After structure reformulation (Type I), the team spent the next most amount of time on synthesis. Synthesis or (Be) expected behavior to (S) structure is the process of transforming expected behaviors into structure which involves analyzing a problem, proposing a solution, analyzing the solution and ultimately evaluating it. Synthesis was the next predominant bar in Figure 16 at the second position for each session.

The team was more solution oriented than problem focused based on the higher percentage of synthesis and reformulations for the transitional processing that occurred. Reformulation is where new variables are introduced into (S) structure, (Be) behavior or (F) function. Also next emphasized by time spent was reformulation II or (S) structure to (Be) expected behavior followed by reformulation III or (S) structure to (F) function. From the qualitative discussion, the team members used analogies to reason through the design process. Interface applications draw heavily from already reasoned design patterns with origins in analogies and metaphors. Analogies can be part of function, behavior and structure and are part of the reformulation process. The team's processes indicate time spent on solutions and analogies were a contributing factor to delivering user-centered designs to satisfied clients.

A breakout of the syntactic process percentages for each of the sessions for both projects is displayed in Table 11.

Table 11

Syntactic Process Percentages

Syntactic Process		125-1	125-2	125-3	Percentage Viewbook-1	Viewbook-2	Viewbook-3
Formulation	R>F, F>Be	00.0	0.5	0.5	19.0	3.8	2.3
Synthesis	Be>S	19.3	22.8	16.4	14.3	6.2	15.1
Analysis	S>Bs	3.5	0.0	7.7	4.8	3.8	3.5
Evaluation	Be<>Bs	3.5	2.1	8.2	0.0	2.5	4.7
Documentation	S>D	5.3	1.6	1.0	0.0	7.5	3.5
Reformulation 1	S>S	40.4	47.1	50.2	28.6	68.8	51.2
Reformulation 2	S>Be	19.3	23.8	15	0.0	6.2	16.3
Reformulation 3	S>F	8.8	2.1	1.0	33.3	1.2	3.5

In the first sessions for both projects, the cognitive effort was focused on the problem (see Table 20 problem structure index for additional support for this conclusion). Table 11 shows the largest percentages for all sessions as (S to S) reformulation I. Meeting one and two of the 125-Year project are more comparable in percentage of time spent on the problem than the Viewbook, but the Viewbook percentage was still higher than other transitional processes. Also, (Be to S) synthesis was comparable across the sessions and the next largest percentage of cognitive effort. In general, meeting one was more problem oriented than solution focused (See Problem Structure Issue Index Table 20 for more detailed and another approach to analysis of the measure of cognitive effort of problem versus solution).

During session two reformulation I synthesis issues continued to dominate transitional processes in the progression of the project collaboration and problem solving efforts. Meeting two for the Viewbook project had the highest percentage of all the processes across all the projects in (68.8%) reformulation I. A contributing factor was, once the problem (F) function and (Be) expected behavior were clarified and analyzed, emphasis shifted to design of content, layout, navigation and style.

The third session had more variations, the Viewbook percentages were higher in most cases across the processes even though the session was more solution oriented than the other meetings. The problem was still being refined by the client and understood by the design and development team. Overall, the projects were different in formulation and reformulation. Formulation and reformulation III were higher transitional processes in the Viewbook than the 125-Year project. As previously stated, an explanation is that less was known about the problem and the function of the Viewbook and more time was spent in the first session questioning the purpose and (Be) expected behavior of the problem to be solved. In the 125-Year project, the percentage of segments coded for the different transitional processes was similar, however; reformulation II was a higher transitional process than in the Viewbook project.

Although the projects were similar in their purpose, requirements gathered and proposed function were not. The first two sessions of the 125-Year were more alike while the second and third sessions of the Viewbook were more similar. The complexity of the projects was not equal, and the 125-Year project although, more complex in the execution of the product, had a clearer direction and problem to solve. The Viewbook had a less clear problem and direction required refining and defining.

However, the process followed for each project and the pattern for time spent on the transitional processes were similar for each meeting. Figure 17, 18 and 19 show the percentage of segments assigned to the transitional processes and illustrate the cognitive effort for each of the sessions on both projects.

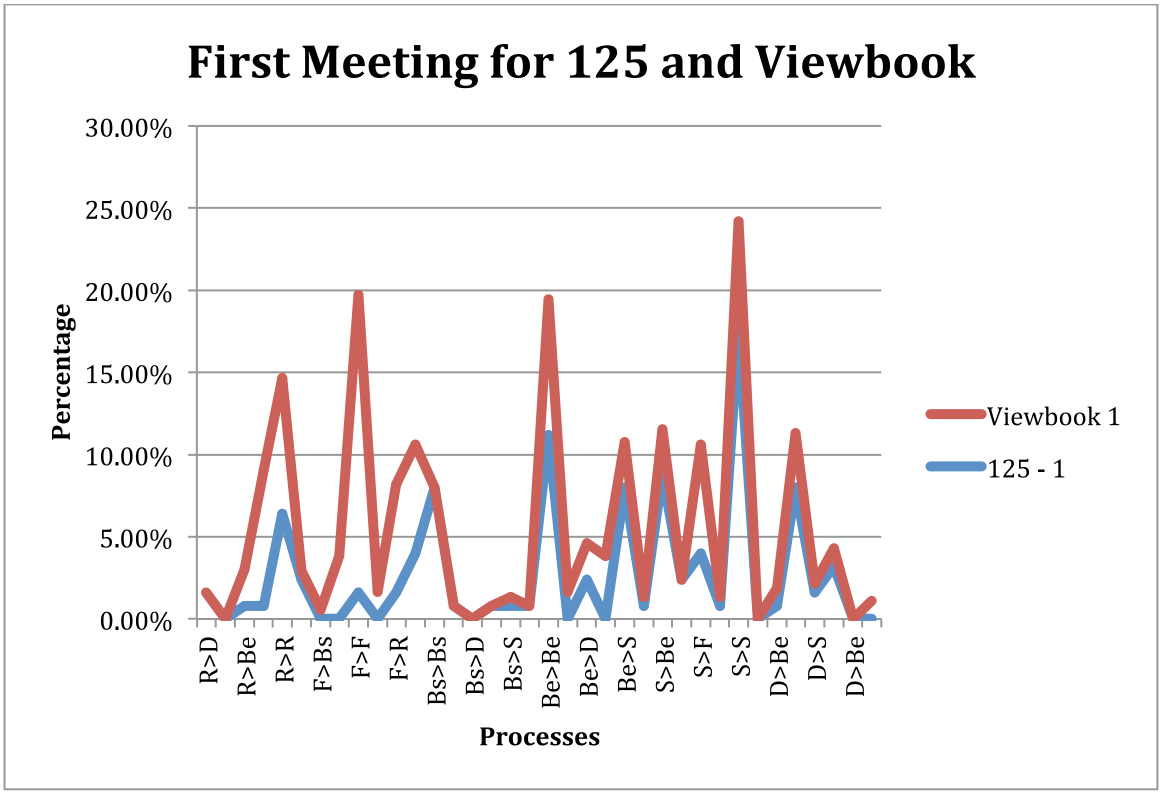


Figure 17 The process percentages of FBS for meeting 1 (Creative Brief).

In the first sessions Figure 17 illustrates the progression of the process and distribution of the cognitive effort spent on the transitional steps. The graph peaks for (R) requirements, (F) function, (Be) expected behavior, and (S) structure. The team's cognitive effort, although more distributed across the FBS ontology in this session than the other two, was as expected and focused on the problem and understanding it to apply design and development.

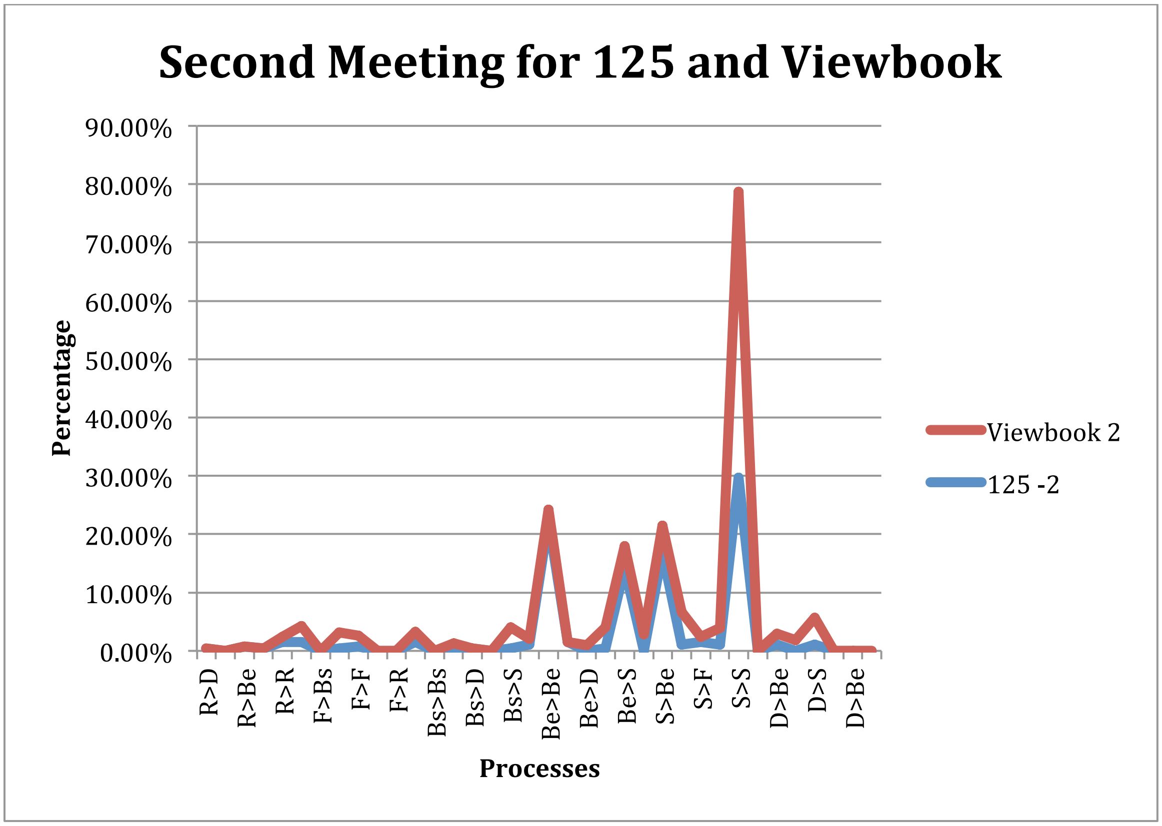


Figure 18 The process percentages of FBS for meeting 2 (Post Design Session).

The second sessions are less distributed across the process and more solution oriented. The (Be) expected behavior and (S) structure are predominant. Figure 18 illustrates the team's focus has shifted from understanding towards navigation, presentation and style. The characteristic of the second session is more similar to the third session with more cognitive effort on (S) structure and (Be) expected behavior.

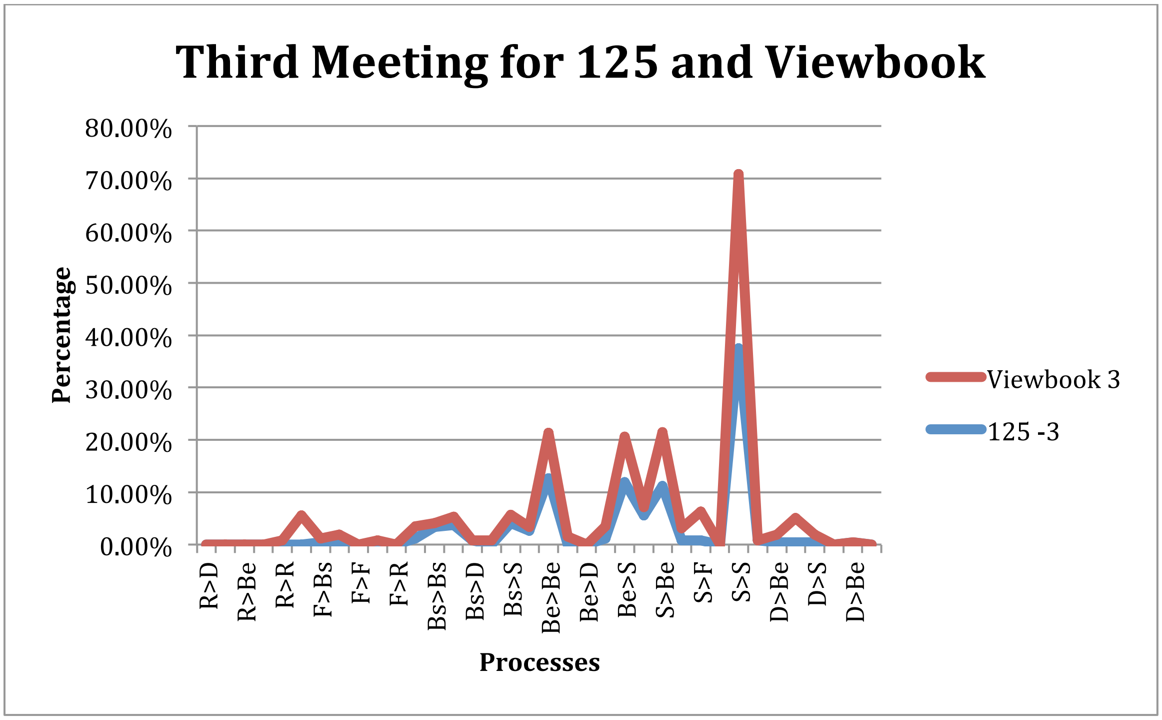


Figure 19 The process percentages of FBS for meeting 3 (Usability).

An explanation for (S) structure and (Be) expected behavior continuing to dominate the third sessions is the team's discussion of design choices and presentation of navigation functions with the client. The client's input in the form of usability was also in (Be) expected behavior and (S) structure. Although most of the cognitive effort for both projects across sessions was (Be) expected behavior and (S) structure, the team started with understanding the problem, compared and suggested examples for approaches, and then moved into solving the problem with presentation and navigation layer discussions.

Semantic Issue Distribution

A linkograph is produced by semantically linking individual design issues and as a result captures the unstructured nature of design sessions. LINKOgrapher version 1.0, a software system is an analysis tool designed to standardize the results and was used to generate the linkograph on which the semantic data was based. The semantic linkograph constructs the vertical distribution of nodes as an index for the overall distance of the links (how far the linked segments are apart). The issue activity is denoted by the horizontal distribution of the nodes during the design session.

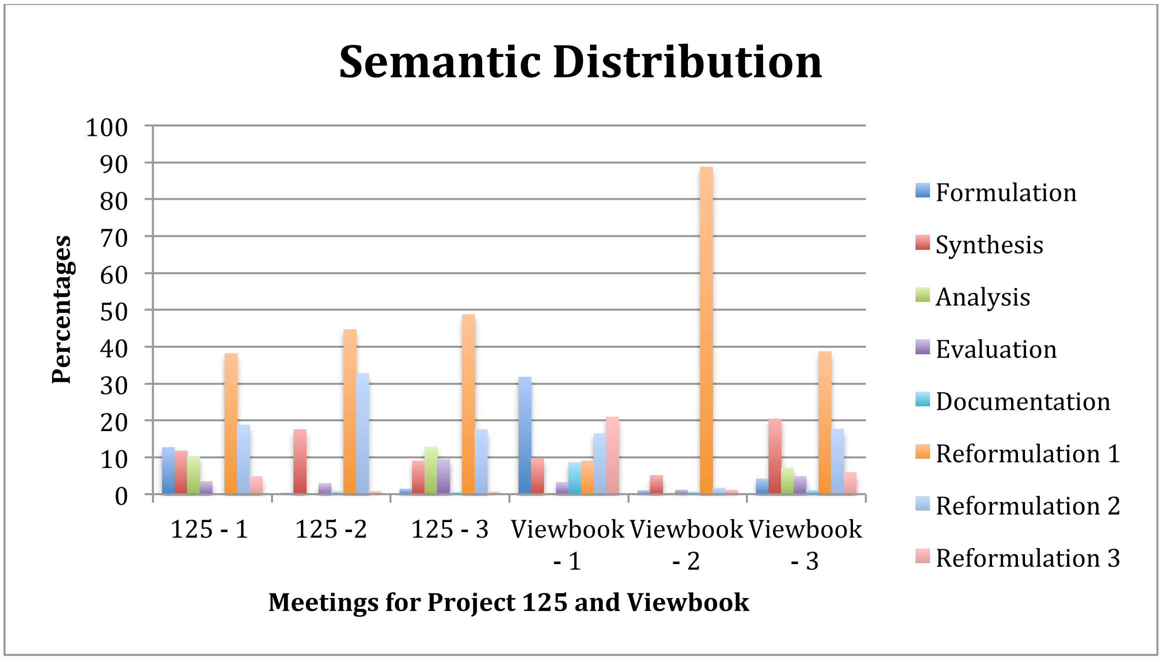


Figure 20 The semantic distribution of FBS for all six sessions.

A transitional process is a link from one segment to the next, and what is found out about the process is dependent on the issues. For example, if the issue is (F) function and it is backlinked to segment (Be) expected behavior, the process is (F) to (Be) and that maps onto formulation. The semantic processes for the six sessions are depicted in Figure 20.

The cognitive effort in semantic issue distribution is comparable to syntactic issue distribution with a slight variation: reformulation I was still the dominant transitional process. In semantic process reformulation II was the next emphasized, then followed by synthesis and reformulation III. In the case of syntactic issue distribution synthesis was before reformulation II. Of particular interest is formulation/reformulation as the largest activity in terms of events and that the vast majority of reformulation is concerned with behavior and structure. This can be attributed to the team's generating novel ideas by analogy and Figure 20 reflects the time spent on it earlier in the process—and provides a quantitative measure of it. This is also supported in the qualitative results observed and discussed earlier. Table 12 presents the actual percentages for each of the transitional processes and distribution across the sessions. Project 125-Year had more data to work with overall; however, the project exhibits similarities to Viewbook in the cognitive efforts of the transitional processes across the sessions.

Table 12

Semantic Process Percentages

Semantic				Percentage			
Process		125-1	125-2	125-3	Viewbook-1	Viewbook-2	Viewbook-3
Formulation	R>F, F>Be	12.7	0.4	1.5	31.8	1.0	4.2
Synthesis	Be>S	11.8	17.6	9.0	9.7	5.1	20.4
Analysis	S>Bs	10.3	0.0	12.8	0.3	0.4	7.1
Evaluation	Be<>Bs	3.5	2.9	9.4	3.2	1.2	4.8
Documentation	S>D	0.0	0.7	0.6	8.6	0.6	1.1
Reformulation I	S>S	38.2	44.7	48.7	9.0	88.7	38.7
Reformulation II	S>Be	18.8	32.8	17.5	16.5	1.7	17.7
Reformulation III	S>F	4.8	0.7	0.6	20.9	1.2	5.9

Focus on problem definition is derived from formulation (12.7%), synthesis (11.8%), analysis (10.3%) and evaluation (3.5%) and mostly occurred in session one of 125-Year project. Viewbook was more distributed across sessions while formulation (31.8%) and synthesis (9.7%) occurred in session one there were obvious clarifications and some revisiting of the problem in meeting three with the inclusion of the client in the session and an additional effort exerted for synthesis (20.4%) and analysis (7.1%).

Formulation and reformulation are part of situated creativity that is defined as the introduction of new variables in relation to the purpose of the product being designed. New ideas come from reformulation of (S) structure, (B) behavior and (F) function.

In these sessions, the reformulations were mostly of structure and behavior. Explicit examples of structure reformulations were: making analogies with other interfaces, and F to F for formulation and Be to Be can be viewed as reflections of function and behavior in many cases. For example, Be to Be occurred when they discussed the navigation structure and the ways it would operate. Studying the links in this way provides both a frequency count as well as a non-linear way of looking at the design process and potentially more representative of the design process as practiced.

Markov Model

Markov chains, also referred to as Markov analysis, examine the sequence of events—they analyze or describe the probability of one event leading to another. The issues from LINKOgraph 1.1 are displayed as a 6 by 6 matrix with the transition matrices probability, which represent a first order Markov process. For example Table 13 represents the numbers in the matrix as the probability of an issue; the probability of an F state being followed by another F state F > F is .22. The probability of an F state being followed by a Be state F > Be and S state F > S is 0.0 and 0.11 respectively. High percentages of the consecutive segments indicate a direct relation.

Table 13

Syntactic 1st Order Markov Model Meeting 125-Year 1

	R	F	Be	Bs	S	D
Requirement	0.53	0.07	0.07	0.00	0.20	0.13
Function	0.22	0.22	0.00	0.00	0.56	0.00
Expected Behavior	0.00	0.00	0.48	0.03	0.38	0.10
Structured Behavior	0.00	0.08	0.08	0.77	0.08	0.00
Structure	0.02	0.11	0.24	0.04	0.51	0.07
Description	0.21	0.00	0.11	0.00	0.11	0.58

As with issues, syntactic and semantic methods there are similarities and differences between the projects and the sessions. The probabilities for each of the issues are listed in Appendix E. The LINKOgraph software produces a matrix for both syntactic and semantic probabilities. Tables 14-19 are a summary of the matrices in Appendix E.

Table 14

Syntactic Markov Session 1 Summary Compare

Requirements >	R, F, Be, S are comparable to both projects
	Bs and D probability for Viewbook, but not 125-Year
Function >	R, F, S are comparable to both projects
	Be, Bs and D were no probability for 125-Year
	Bs probability for Viewbook, but only .02
Expected Behavior >	R, Be, S and D are comparable for both projects
	Structured behavior for 125-Year probability but only .03
Structured Behavior >	R, F, Be, S and D are comparable
	Bs for 125-Year and very different at .77 probability
Structure >	Very comparable in probability across issues
Description >	Be, Bs and D are comparable
	R and S are higher probability for 125-Year than Viewbook
	F is higher probability for Viewbook than 125-Year

Session one syntactic summary from Table 14 is the first internal meeting of the project and was dominated by requirements, function, expected behavior and structure. In general, session one across the two projects probabilities for requirements, function, expected behavior, structured behavior, structure and description were similar. The differences were in requirements to a transition state of structured behavior and description and description to a transition state of requirements and structure for the Viewbook project. The differences were in a potentially less clear creative brief and understanding of the purpose of the design project and discussion on deliverables used as description and documentation for the project. The probability of structured behavior to another state of structured behavior was .77 for the 125-Year project. This supports that the team was already collaborating on the proposed solutions that there were multiple contributions to the designs derived functionality.

Syntactic summary in Table 15 for session two of the projects has some similarities, but it also exposes some divergences of the projects in the transition events. For function to have the next chance that the next state is function or structure.

Table 15

Syntactic Markov Session 2 Summary Compare

Requirements >	R and S are comparable
	Be is a .25 probability for 125-Year and 0 for Viewbook
Function >	F and S are comparable
	R is a .25 probability for 125-Year and 0 for Viewbook
	Be is .43 probability for Viewbook and .12 for 125-Year
Expected Behavior >	Be and S are comparable
	F is .29 probability for Viewbook
Structured Behavior >	Be, S and D is .33 probability for 125-Year
	Be and S is .25 and .75 respectively for Viewbook
Structure >	S is comparable
	Be is .31 probability for 125 year
Description >	Comparable with low activity across issues and projects

For the 125-Year project R > Be and F > R is a probability of .25 and 0 for the Viewbook. With this observation of the transition events the 125-Year project team is validating requirements with expected behavior and function and as a result validating and design decisions and direction. For S > S to be similar and assuming that some of the S > S events are reformulations for both projects, but different for S > Be for the 125-Year project at a probability of .31 indicates that these projects are likely at different stages in the design at this point in the respective projects. The probability for description was low for both projects in this session representing that the teams were not focused on the description and deliverables of the project at this point in the process.

Session three of the Markov syntactic summary in Table 16 presents some similarities and some differences in the projects issue transitions, as did session two.

Table 16

Syntactic Markov Session 3 Summary Compare

Requirements >	No requirements for 125-Year
	R is .14 probability for Viewbook
	S is .56 probability for Viewbook
Function >	Little to no function for 125-Year
	Be is .25, Bs .12 and D is .12 for Viewbook
Expected Behavior >	Be and S are comparable approximately .40 probability
	Other issues are comparable and low activity
Structured Behavior >	Be, Bs and S are comparable and .20 plus probability
	F is .12 for Viewbook
Structure >	S is approximately .60 for both 125 and Viewbook
Description >	Comparable with low activity across issues and projects

Expected behavior and structure indicate design decisions had been made and progressed to the point that the client was reacting to the design and providing feedback on functionality, navigation and style decisions. For the 125-Year project the team was beyond collaborating on issues related to requirements and functions. Although this session included the client the Viewbook project had a probability of .14 for R > R and R > S .56 so the team was still validating requirements and design direction based on requirements this time with the client.

The semantic data provides another technique for developing insight into design activities. There are more divergent transition states in the design processes in the comparisons of projects of the semantic Markov data, Tables 17-19 then in the syntactic Markov data.

Table 17

Semantic Markov Session 1 Summary Compare

Requirements >	R, Be, S, and D are comparable probability F is .34 probability for Viewbook
Function >	Be and S are comparable probability Bs is .32 probability for 125-Year R and F are .14 and .33 probability for Viewbook
Expected Behavior >	Be and S are comparable probability F and D for Viewbook are .32 and .18 respectively
Structured Behavior >	Bs is .92 probability for 125-Year F, Be, S and D (.28, .30, .18 and .12) probability respectively for Viewbook
Structure >	Be are .26 probability for both Bs and S .14 and .52 for 125 year respectively R, F, S and D for (.14, .32, .14, and .13) for Viewbook respectively
Description >	R is .38 and D is .57 probability for 125-Year F is .32, Be is .28, S is .13 and D is .17 probability for Viewbook

Semantic session one in Table 17 shows there are similarities for the distribution of the probabilities in requirements, function, expected behavior, and structure. For the Viewbook R > F is a probability of .34 and an indication that the purpose of the project needs further understanding. The Be to S probability can be seen as the probability of a synthesis process when a Be event occurs. Similarly, the S > S transition probability can be seen as type I reformulation probability when an S event occurs and it was a probability of .52 for the 125-Year project. F > Be indicates comparable probability for both projects and is seen as evaluation. F > Bs is a .32 probability for the 125-Year project and can be attributed to comparing examples and analogies that already exist as examples to model. This can also be the high percentage of Bs > Bs at .92 probability for project 125-Year. Although type I reformulation is higher for the 125-year project (.52), type II reformulation is the same for both projects at probability of .26. Type II reformulation is .32 for the Viewbook and typically considered a rare transitional occurrence.

The second session of semantic Markov data (Table 18) is very similar in the distribution of probabilities, but the percentages are generally higher or lower depending on the FBS process. The exception to this is F > Be which was comparable in both sessions.

Table 18

Semantic Markov Session 2 Summary Compare

Requirements >	Probability S is .56 for 125-Year and .94 for Viewbook
	Be is .42 probability for 125-Year
Function >	Be is comparable
	Probability S is .73 for 125-Year and .27 for Viewbook
Expected Behavior >	Probability S is .29 for 125-Year and .50 for Viewbook
	Probability Be is .64 for 125-Year and .17 for Viewbook
Structured Behavior >	Probability Be is .83 for 125-Year and .26 for Viewbook
	S is .34 probability for Viewbook
Structure >	Probability S is .55 for 125-Year and .90 for Viewbook
	Be is .40 probability for 125-Year
Description >	Be is .68 probability for 125-Year
	Probability S is .27 for 125-Year and .84 for Viewbook

The probability of R > S was .56 for the 125-Year project and .94 for the Viewbook project. Both projects in this session designed by referencing design elements in other examples by case based reasoning or precedent based-design using parts of previous solutions in developing new solutions. The high probability of Be > Be at .65 and Bs > Be at .83 for the 125-Year is an indication the teams activities of evaluation were predominant in this session.

Both projects had a high biased toward structure related activities in this session. The semantic data also indicates the projects were at different points in the design process, but more importantly the semantic data successfully shows the 125-Year project had more functional and behavioral complexity.

Table 19, which describes the summary of the third session semantic Markov data, is the most similar in probability and distribution across the FBS processes.

Table 19

Semantic Markov Session 3 Summary Compare

Requirements >	No requirements for -125-Year
	R and Be .12 and .19 respectively
	S is .56 probability for Viewbook
Function >	Be is comparable at .29 probability
	S is comparable at .30 probability
Expected Behavior >	Be .55 for 125-Year and .24 for Viewbook
	S is .26 for 125-Year and .54 for Viewbook
Structured Behavior >	Be is comparable at .25 probability
	S is comparable at approximately .30 probability
	Bs is .47 probability for 125 year
Structure >	S is comparable at approximately .55 probability
	Be is comparable at approximately .22 probability
Description >	S is comparable at approximately .50 probability
	Be is .25 probability for Viewbook
	Bs is .36 probability for 125-Year

The semantic data for the third session was very comparable in the projects and is an indication that the activities with the client were similar in both projects even though the projects diverged and resulted in different products. Type I and type II reformulation were almost identical for both projects with the client present and is an indication they were validating their design decisions with the client in the session. A point of interest is the approximate probabilities of event states were very similar even though the team was meeting with two different clients.

The project similarities exist by the type of projects they were and both projects used the same format for meeting and collaborating. The syntactic data exposed more differences in the process and the transitions emphasized were different for the two projects. The Markov semantic data shows the emphasis of the transitions for each of the projects was very different. Although the team appears to work through the process in a similar manner, the projects had different purposes and the purposes resulted in the transition process states having different outcomes. In summary of First Order Markov chain, the results from the two analyses not only match my observations and qualitative analysis, but also provide further insight into the design activities quantitatively.

Entropy Measurement

According to Gero (2007) fully linked and empty linked linkographs represent substandard design processes. An empty linked linkograph represents neither generation nor solidification of ideas; a fully linked linkograph suggests fixation and lack of diversification of ideas. A good design process has a balance among the links, which is represented by entropy. Forelink entropy measures idea generation opportunities in terms of new creations or initiations. Backlink entropy measures opportunities according to enhancements or responses. The LINKOgraph software produces a graph of entropy from the linkograph. Fixation should manifest in a linkograph as heavy linking from later design issues to a grouping pattern of earlier design issues. If the idea in a segment is weak, it will not have a lot of forelinks and produces low entropy. However, if an idea gets many forelinks this indicate fixation, which is also indicated by low entropy. Similarly if an idea is not very original it will not have backlinks and the resulting entropy is zero.

For the 125-Year project in all three sessions, it appears that entropy occurs at two or three points in the meetings. In each of the meetings, the fixation is around a different issue; however in each meeting there is a different aspect of the design under discussion. Figure 21 graphs the entropy for session and illustrates where entropy may be occurring in the session.

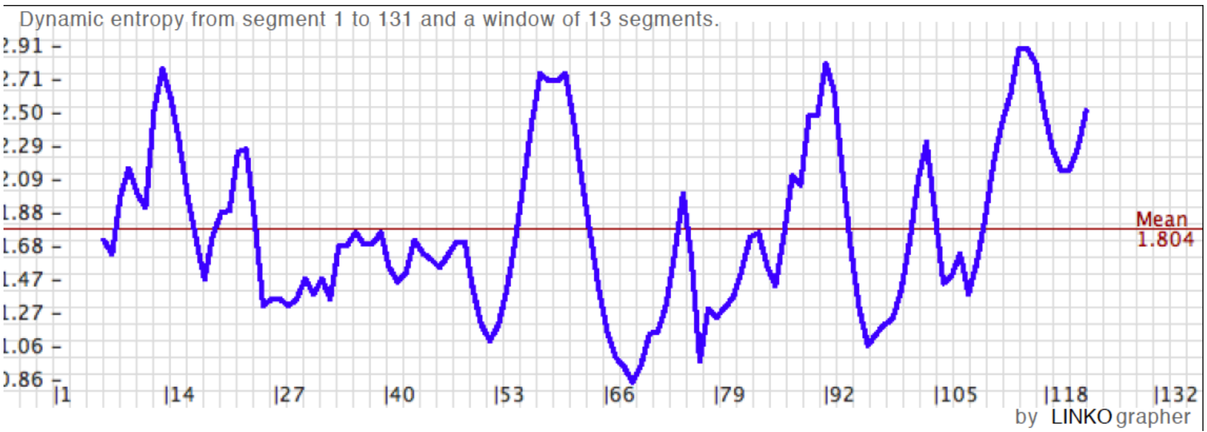


Figure 21 Entropy for the 125-Year meeting 1 (Creative Brief).

A rapid drop in entropy appears to occur around the expected behavior related to navigation and the concept of a timeline and how the constituent would view and navigate the timeline in session one for the 125-Year project. Segment number 67 is coded as Be and the team is discussing the design pattern that will be used for the timeline and then the style of the structure and the way it will align the content with the navigational elements. Another occurrence in this session was segment number 98 coded S with respect to the process of delivering the design concept based on interpretation of the requirements, to the client and what will be the process and outcome of limiting them to the recommended structure.

The second session of the 125-Year project had two rapid drops in entropy as points of fixation based on the entropy graph in Figure 22. The numbers 72 through 78 with

S>Be>S>S transitions was deep and spanned a few segments probably type 1 and 2 reformulation processes and fixating around the structure or look and feel and how the content will be displayed; the background and wrapper of the actual artifacts and how they will be treated to highlight and showcase them.

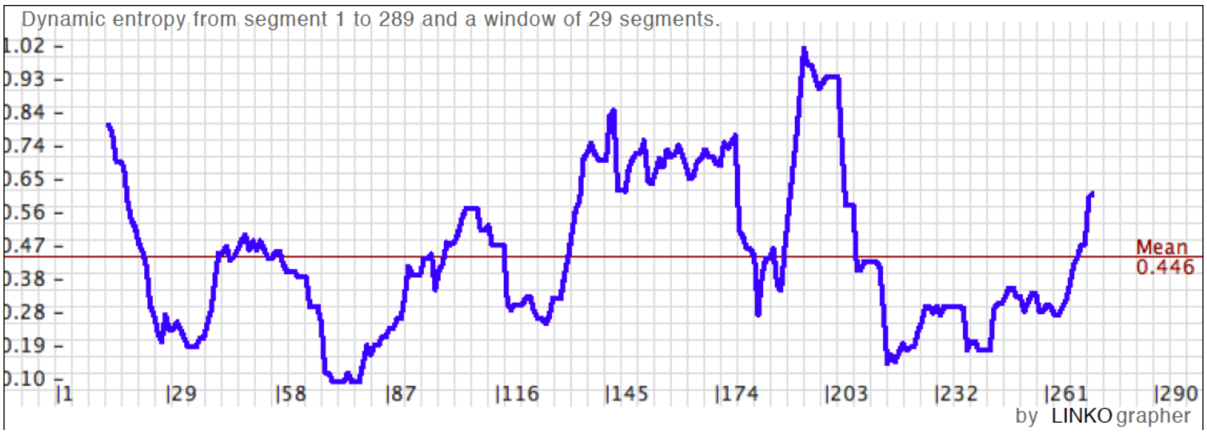


Figure 22 Entropy for the 125-Year meeting 2 (Post Design Session).

A second drop in entropy point later in the session was with respect to functionality at segment number 220 and was focused on how the system will perform for clients (or not which was the ultimate decision to do for them) inputting the large amount of content needed to be added to populate the system for presenting the historical content desired to celebrate the history and milestones of the institution. Another comparable, but not as low point at segment number 242 was issues fixated about the location of the content and navigational links from other places on the UST site for access to this content for the intended audience.

The last session of the 125-Year project that included the client is depicted in Figure 23 and represents two-drop points in entropy. Structured behavior segment number 23 focused around how the content will be interacted with and the structure and functionality of the expanded display of more in-depth interaction, when the constituent identifies an area of interest. For example, designer said, “When I have selected a point in the timeline and want to know more about 1988 the year I graduated, as I drill down into the content through navigation what is my experience and the systems expected behavior as I attempt to learn more about the artifacts?”

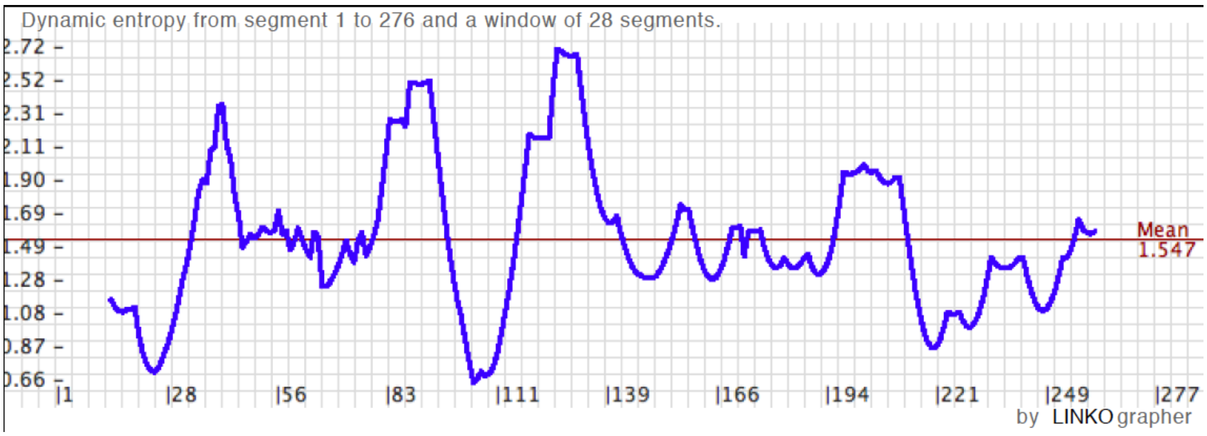


Figure 23 Entropy for the 125-Year meeting 3 (Usability).

Another point of fixation for the team in the third meeting is the importance or lack of value to a design treatment that encompassed a unique identifier of the system in the form of a logo, mark or some type of identity. Type I reformulation was S>S>S>S for segment number 104 through 108.

In all three instances of meetings it appears that fixation occurs around the complicated decisions that make up the system. They are: behavior of the system with respect to interaction and navigation; structure of the system; and as a result content displays and limitations for the constituent navigating it including a sub branding element and the method for delivering the design and functionality to the client for which it is being built.

In the case of the Viewbook project across sessions less balance occurred among the links. As the sessions progressed from the first session to the second session fewer new ideas were introduced. The group fixated at four points in session one as depicted in Figure 24.

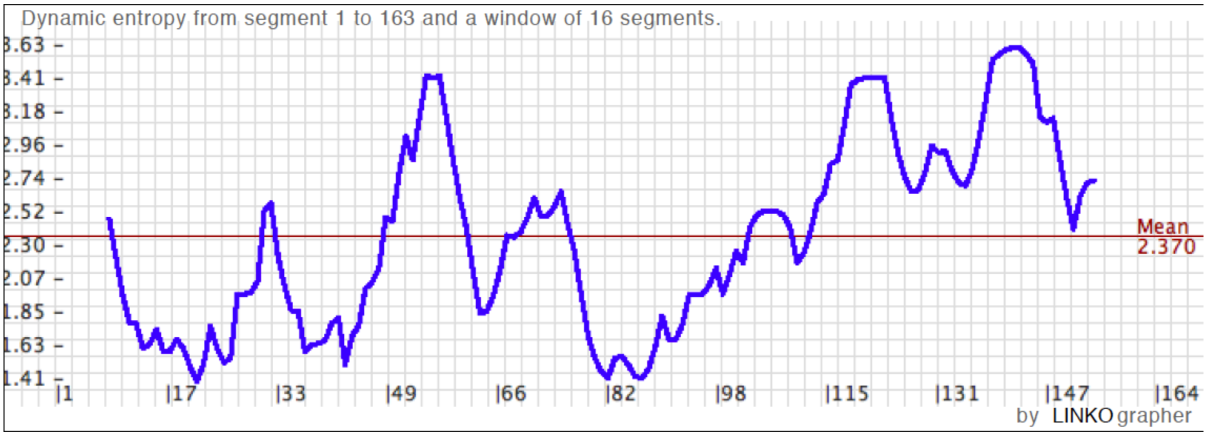


Figure 24 Entropy for the Viewbook meeting 1 (Creative Brief).

The initial session of the Viewbook projects points of fixation are at segment numbers 20, 42, 82 and 86. Although segment number 86 appears to be part of 82, it is a slightly different requirement. In number 20 the team was evaluating the purpose of the application and whether it would integrate with other already created functionality on the site. Then again in segment 42 the team went back to purpose and a discussion of existing enrollment content and how that would be integrated with this new destination application. Lastly, another analysis of the intended audience for the proposed function at segment number 82 where the team discusses if the design is to be for perspective students only or did it include parents that are now assisting with applications and finances online. Based on the audience discussions an additional point of fixation on the functionality and expected behavior for video occurred, specifically what types of video need to be accommodated and how long it will be expected to play.

Session two for the Viewbook project was more of the same analysis and synthesis of audience and categorization of content, while little new ideas were introduced. Figure 25 illustrates the entropy for the session and shows two point of fixation towards the end of the session.

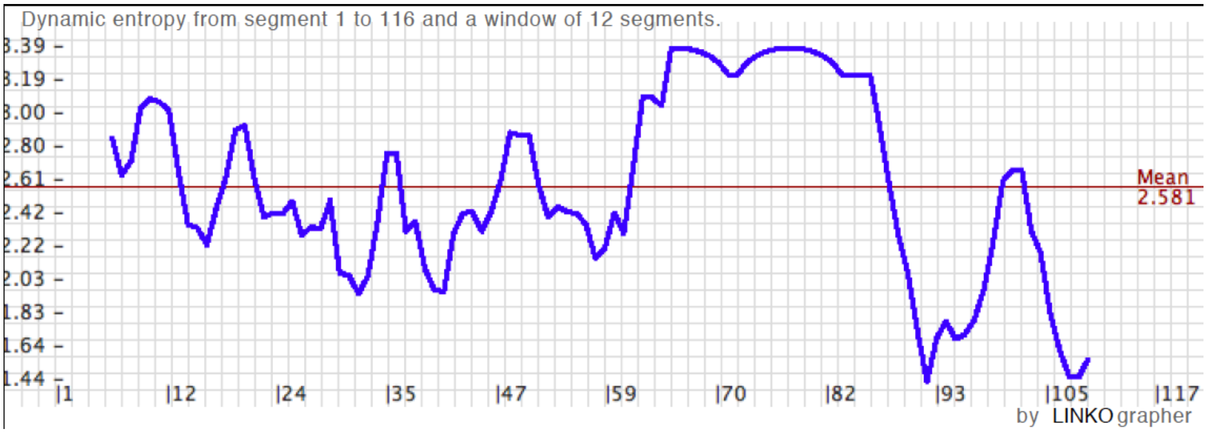


Figure 25 Entropy for the Viewbook meeting 2 (Post Design Session).

The first point occurs at segment number 93 and is concerned with content categorization for the audience. The second point occurs at 108 and is a type I reformulation on structure and what the proposed content categories would be to present to the client based on current design direction.

The graph in figure 26 is of the third meeting of the Viewbook project. The first point of fixation was segment number 9 and was a discussion around the structure and style of the designed interface. The remainder of the session was dominated by the method chosen for putting in new and updated content over time.

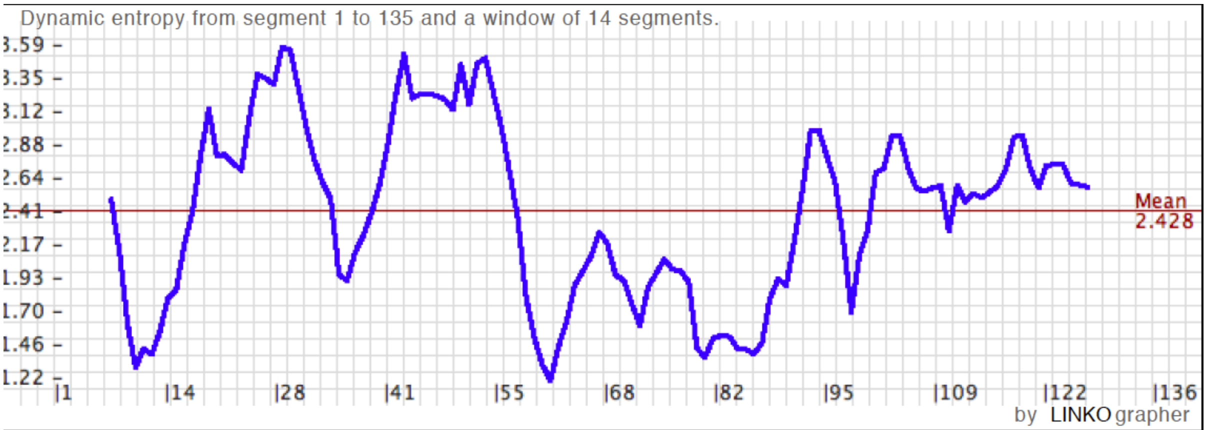


Figure 26 Entropy for the Viewbook meeting 3 (Usability).

A significant difference in the Viewbook from 125-Year project was the functionality of the designed deliverables included tools for the client to prepare and insert their own content once the designed application was delivered. The team integrated a piece of software for managing images and video into the interface to make it easy for the client to self sufficiently keep the content fresh and up to date. At segments number 61 and 80 the evaluation and type II reformulation was focused on the way the software worked with content and categorized it based on an understanding of the audience.

The diversification of ideas in Viewbook was lower than 125-Year project and during the first session they decided the design and discussion and analysis of structure for content organization and type dominated. There was also a significant amount of discussion and evaluation of intended audience, as that was not clearly conveyed by the client.

Although more projects need to be analyzed to show that an entropy measure of linkographs could be a useful tool to evaluate idea development (Sessions one through six are graphically represented in Appendix F). Figure 27 is the linkograph for 125-Year project session one and Figure 28 is the linkograph for Viewbook session one and supports the potential correlation between the entropy of a linkograph and the productivity of the design activities. The linkograph in Figure 27 illustrates a balance among links and indicates a good amount of idea generation occurred in the session by the forlinks and backlinks.

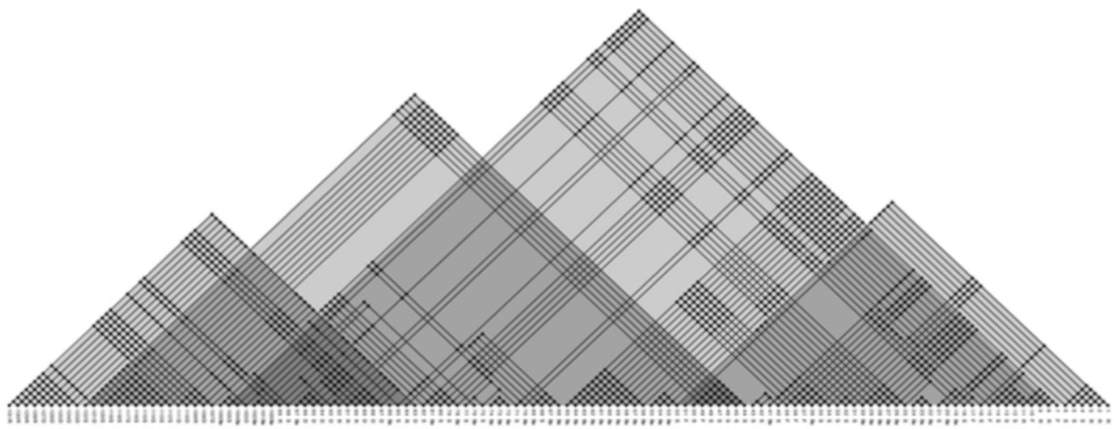


Figure 27 Linkograph of Session One 125-Year Project.

The linkograph in Figure 28 is a heavily fully linked linkograph illustrating fixation and a potentially premature commitment to an idea not fully realized or evaluated.

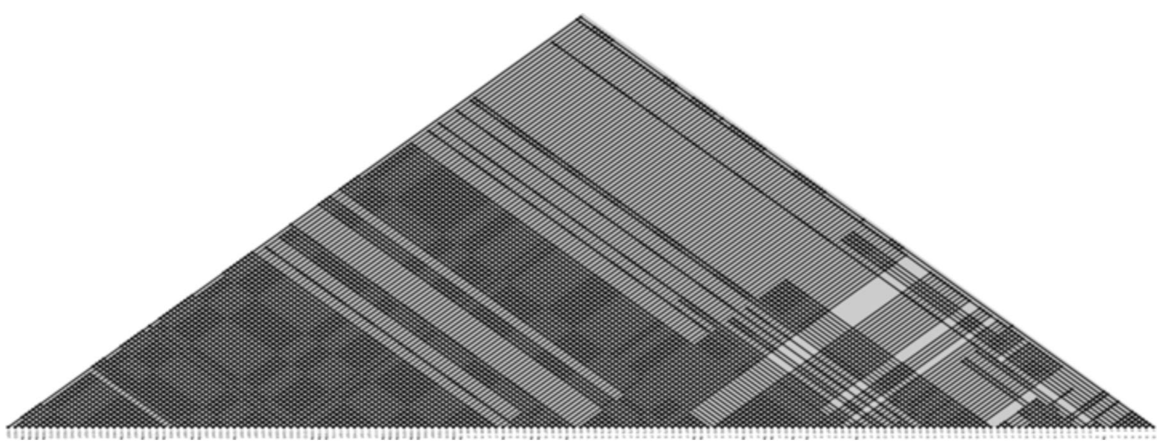


Figure 28 Linkograph of Session One Viewbook Project.

It can be observed that the two sessions produced very different shapes of linkographs. This is sometimes referred to as the signature of the design session. In the case of these two projects, the Viewbook project was a quickly converging process that started early, in the first session, and idea development opportunities lessened as the sessions progressed and for 125-Year convergence appeared to start in the second session. Further analysis is needed to determine if this was because 125-Year was more complex than the Viewbook and if there were contributing factors to the early convergence of ideas.

Summary

In this chapter qualitative and quantitative results have been presented. The FBS methodology that was currently being used across the design discipline for its versatility and utility has been applied in a variety of measures in this case study to attempt to gain understanding of the design process. According to experts in the FBS ontology, ten sessions is an acceptable number for analyzing the process to arrive at conclusions; the sessions measured should have at least one hundred segments and ideally they should be comparable. This case study met the 100-segment minimum for both projects and was an acceptable comparison for analysis; however more projects are ideal to produce more reliable results. One of the challenges in comparing multiple cases is the difference in the lengths of the design session that makes quantitative analysis difficult.

This case study used issues, syntactic, and semantic distributions to measure the cognitive effort of the teams design process based on the linkographs generated by the LINKOgrapher software. Issues distribution analyzed the issues for the goal of changing a set of functions into design descriptions to describe the design process. Syntactic and semantic issue distribution measured the design process as transitional processes, as a closer to actual simulation of the actual process of designing. To attempt to predict the probability of a transitional state Markov chains were used and entropy was used to measure idea generation and consolidation or convergence. Researchers continue to use different approaches to studying the design process and there are still a variety of methods to be proven.

Chapter 5

Findings, Conclusions, and Implications

Conclusions are drawn in Chapter 5 regarding design problem-solving processes, beginning with a brief review of the Findings of this study regarding the design team's cognitive and production processes. The implications of those findings for design practice and design education are addressed in more detail in the Conclusions. The section on Implications is a discussion of issues that have been raised and some suggestions of what should be done in Practice and Education and Future research suggest some possibilities for further research in this area. The Summary section concludes the study with a review of the methods used in this research study.

Findings

Although these projects were similar in process, team composition, and type of user experience design, the results of the research were not similar in the outcome. Through observation and measurement of the activities of a small team working together, this study analyzed the process of a user experience design team. Although, this study only analyzed the data from two design projects, it appears that the design teams' process is similar if not the same. In addition, their requirements and adherence to a process do not change even though the final design products were unique and the solution to the problem ended up being different for the two projects. Although not significant enough to make general recommendations, the results of this study suggest the design teams studied were found to have a common process. An initial indication is that the way design teams work is not a magic art and does follow a repeatable process that does not vary much; however, more design projects need to be analyzed to produce generalizable results.

An important aspect to cognitive effort is the time spent either on the problem or the solution. A team may spend more time on the problem than the solution or visa versa for a variety of reasons such as: new member to the team, team is new to the problem, the team's experience with the particular requirements, etc. The problem structure index in Table 20 is a summary of the team's cognitive effort for the 125-Year and the Viewbook projects and describes whether the emphasis was a problem focused or a solution focused sessions. As was seen in the issue distribution, the 125-Year project generated more new ideas, the problem was better understood, and the expected experience for the user was well represented with case-based reasoning and design examples to leverage for the solution. This is additionally represented in an analysis of the problem structure index. The closer to 1.0 the index correlates to is time spent on the problem over the solution.

Table 20

Problem Structure Indices

Percentages						
Problem Structure	125-1	125-2	125-3	Viewbook-1	Viewbook-2	Viewbook - 3
Issue Index	0.93	0.93	0.33	4.57	0.32	0.57
Syntactic Index	0.42	0.37	0.20	1.10	0.14	0.30
Semantic Index	0.24	0.05	0.34	0.47	0.02	0.23

The issue index of the problem structure suggests the first design session for both projects was focused on the problem and is to be expected for an initial meeting. However, the Viewbook is more than 4 times larger than the 125-Year project. The second 125-Year session was heavily focused on the problem and the percentage was identical to the first session. The second session for the Viewbook was more solution-oriented. The third session of the 125-Year project was solution oriented while the Viewbook was about half problem focused and half solution-oriented indicating that there were still unresolved questions and understanding about the problem the Viewbook was intending to solve.

In the case of the Viewbook it appears even though they were heavily focused on the problem after the designers synthesized a solution they were able to understand important issues and requirements of the problem. Ideally, the designers should have multiple ways to represent design problems and solutions such as wireframes, mock-ups and requirements documents (in the form of use cases) as used in these case studies. Even with requirements for the Viewbook, it appears they were less clear about what the problem was solving and referred to fewer examples before settling on a solution. Also, they did not appear to generate as many ideas, but the desired goal was ultimately delivered to the client's expectations. For the 125-Year project they were provided with several examples by the client and had their own examples to contribute to the discussion for an approach to the problem. The solution was delivered as expected and appeal and satisfaction was favorable based on the more solution-oriented percentage of .33 percent time spent on the solution in the usability meeting.

In this study a creative brief was used for the designer's background and understanding of the problem. In both projects the team was provided a couple of examples to frame problem-solving themes; they used the structure to react and compare the success of the solution to then generate solution concepts to their design problems. These examples were also used to communicate those concepts that they felt were successes and provided jumping off points in their design concepts. In addition, the team in this study, at some point, put themselves in the place of the intended audience and user, describing in the first person likely scenarios of use to identify problems and opportunities and to evaluate their proposed solutions.

In the case of the Viewbook, even though it was only one project, some issues related to the requirements and understanding of the client and user merit discussion. Requirements are typically gathered at the beginning and depending on the approach different tools and resources are leveraged. These tools are used to communicate the iteration of the design work to convey and validate the proposed solution. Some examples of tools interaction design teams use include: competitive analysis report, audience personas, creative brief, content inventory, site map, flow diagram, and functional specification. Other examples include: users stories, use cases, wireframes, database schema, experience prototype, design mock-ups, storyboards, templates, test plans, usability reports, heuristic evaluations, analysis reports, search engine optimization reporting and style guide. They are not all used in every project and depending on the scale and scope of the project only the creative brief, wireframes, requirements (in some form) and mock-ups may be necessary to complete it. Even when steps in the process are followed user experience is an important requirement to satisfy and if the user does not perceive the design to be as expected there are costly results in the form of wasted time or lack of use or adoption as a result.

Based on the signatures of the linkographs, in the 125-Year project, moves were inter-related but not totally connected, indicating that there were lots of opportunities for good idea development. For the Viewbook all moves were interconnected: this shows that this was a totally integrated process with no diversification, hinting that a pre-mature crystallization or fixation of one idea may have occurred, therefore a very low opportunity existed for novel ideas.

The six episodes varied in length but were approximately 60-minute sessions. The semantic and syntactic design information was captured to evaluate requirements and process opportunities. Figures 29 – 31 show the percentages in each of the FBS categories in relation to the process. Figure 29 places the first session of the 125-Year project next to the Viewbook session. For the 125-Year project the highest percentages are in the structure and behavior classes. In this protocol these high percentages are due to the frequent use of analogies with other products and situations.

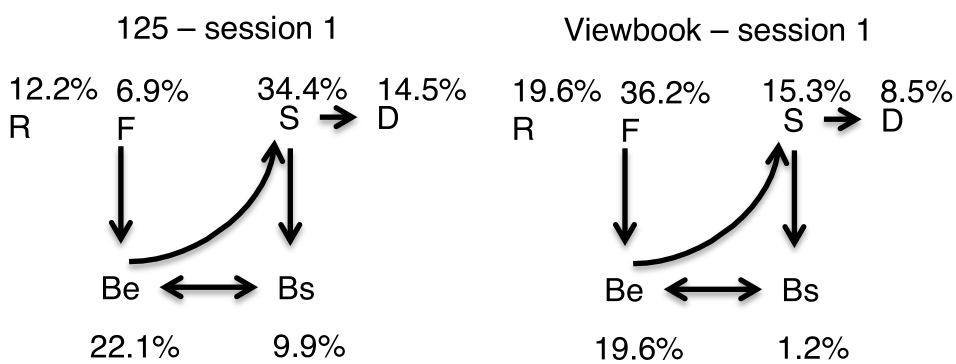


Figure 29 FBS percentages session one.

For the Viewbook's first session more time was spent on function than any other class of protocol because of the lack of clarity around the purpose and goal of the project.

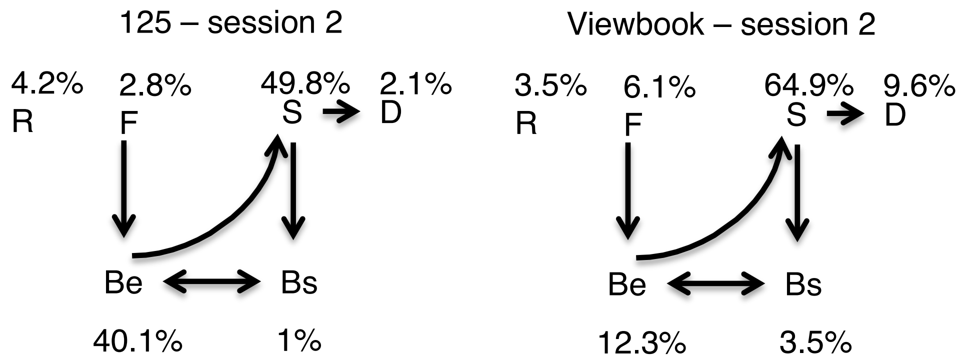


Figure 30 FBS percentages session two.

For the second sessions, the 125-Year project process was still highest for behavior and structure. Structure is slightly higher illustrating that the team was beginning to process more style elements. The second session of the Viewbook was heavily structure-focused and this high percentage was due to the depth of the application and focus on look and feel elements. By the second session, the team had determined that a tool would deliver the content and they spent more time discussing the tools design constraints because they did not need to build a complicated content importing system for the Viewbook like they did for the 125-Year project.

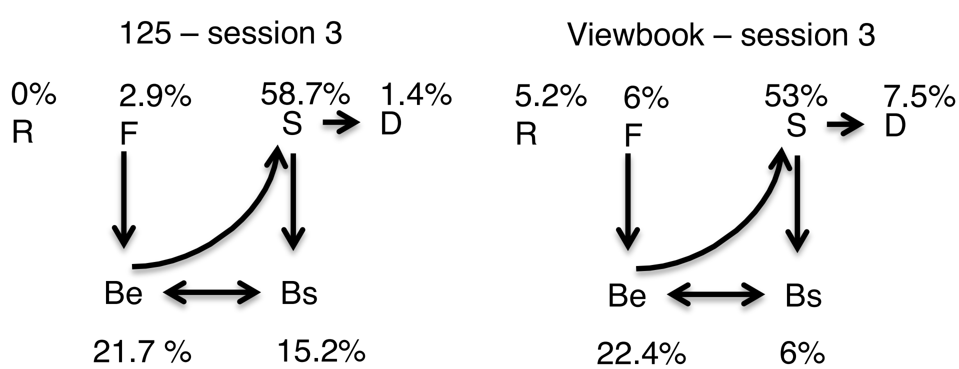


Figure 31 FBS percentages session three.

The third session for both projects illustrated in Figure 31, were very similar in that the team walked the client through the navigation and behavior of the application along with delivery of the design decisions for the interface.

Even though there are slight variations in the sessions and the 125-Year project had more data with higher percentages as represented in Table 21, percentages of all the processes derived from codes and links indicate that overall (S) structure (46.08) and (Be) behavior (26.41) are the highest percentages of the teams design process efforts.

Table 21

Total Process Percentages Across Sessions Transition Matrix

Requirements	%	Function	%	Structured Behavior	%	Expected Behavior	%	Structure	%	Documentation	%
R>D	0.28	F>Bs	0.28	Bs>Bs	1.85	Be>Bs	1.20	S>Bs	2.03	D>Bs	0.18
R>Bs	0.00	F>Be	1.29	Bs>Be	1.39	Be>Be	12.65	S>Be	10.16	D>Be	1.02
R>Be	0.65	F>F	3.60	Bs>D	0.28	Be>R	0.83	S>D	1.57	D>D	2.31
R>F	1.57	F>D	0.37	Bs>F	0.18	Be>D	0.74	S>F	2.86	D>S	1.29
R>R	2.68	F>R	1.29	Bs>S	1.85	Be>F	1.66	S>R	0.74	D>R	0.55
R>S	1.66	F>S	2.68			Be>S	9.33	S>S	28.72	D>Be	0.09
										D>F	0.18
	6.84		9.51		5.55		26.41		46.08		5.62

The transition matrix in Table 21 is a signature that summarizes the transitions between all the FBS events. These transitions provide a rough idea of the distributions of the eight FBS processes by assuming that high percentages of the consecutive segments indicate a direct correlation from one process to the next. The processes most transitioned between were Be > Be, S > Be and S > S with reformulation I at 28.72 percent and reformulation II at 10.6 percent. Comparing these processes informs us of the characteristics of a session. For example segment 19 “We don’t see the whole everything on the 125-Year timeline at one time right? You see the decades and then you click on the decade and see…” coded as Be transitioned to segment 20 “That’s what they are proposing and that’s a challenge so we’ll have to see if we can figure out a way to make 125 years be easily accessible. That’s still out there." also coded as Be. As more insight is gained into design activities better understand: 1) communication differences, 2) cognitive styles and team compatibility, and 3) issues that might cause or take longer to arrive at a structure or behavior decision can be realized.

Markov analysis, based on the probability of a relationship with the last event, provide another technique for developing insight into design activities. The Markov analysis data is summarized in Table 22, see Appendix E for the complete results. The Markov model for the 125-Year project for the syntactic data consistently demonstrates across all three sessions that the team spent most of the time transitioning between the three reformulation phases: reformulation of structure, reformulation of expected behavior and reformulation of function. The Viewbook had reformulation I in common; however the next dominant transition was S > Bs or analysis of the structure producing derived behavior, this could have been because the team selected a tool instead of building one and began emphasizing the style constraints. However, in the Viewbook project the team was transitioning from S > F and processing a reformulation of function. This indicates the purpose either changed when the client saw what was presented as a solution or the purpose was not yet fully understood.

Table 22

Summary of Markov chain data 40 percent or higher

Syntactic					
125-Year			Viewbook		
S > F	S > F	S > F	S > Bs	S > Bs	S > F
S > Be	S > Be	S > Be	S > S	S > S	S > Be
S > S	S > S	S > S			S > S
Semantic					
125-Year			Viewbook		
S > S	S > F	S > Bs	Nothing	S > Be	S > Be
S > Be	S > S	S > D	above 40%	S > S	S > S
	Be > Bs			S > D	S > D

The project session coding was arbitrated and reviewed several times. According to Gero (2011) there still may exist some unreliability in the semantic data. However, based on the qualitative result discussed earlier there were differences in the projects based on where the teams were in understanding the client's purpose and this is again demonstrated in the Markov model semantic data. The 125-Year project starts out with reformulation I and II, transitions to reformulation II and III along with expected and structured behavior transitions and ending with structure to structured behavior and structure to description. For the Viewbook the process was similar in reformulation I as a predominant emphasis in the process; however, the team's process for the sessions was more similar in the second and third sessions. One possible reason is that even though the three sessions were the same steps in the process, the design process was not at the same point in understanding and conveyance of the idea. Although this is just one possibility and further data is required to determine the actual reasons for the differences in interaction design projects.

Another method of further understanding the behavior of designers is gained by examining the information of their protocols. In this way the information is a measure of the potential of a system, rather than its semantic content. Kan and Gero (2009) posit that there is a potential relation between the productivity of design activities and the entropy of their corresponding linkographs. The dynamic entropy only takes the structure of the linkographs into account and currently ignores the codes in the segments, providing a view of the commitment and fixation of a design team. There were points of commitment and fixation in all six of the sessions for both the 125-Year and the Viewbook projects.

The projects third sessions were intended to address usability and the client's reaction to the use and design decisions of the interaction design projects. These were informal sessions and according to Fallman (2008) who suggests that organizations do not know how to leverage design in a concrete way and in the face of looming deadlines clients choose concrete tactics where they can estimate the outcome. A result is they do not understand how to leverage user experience and the work going into those activities to apply them to the success of the project. A user's experience is not just about content, or look and feel, or a subjective expected behavior based on usefulness or function, reinforcing a desire to use a product or service. The outcome is whether they will re-engage or tell everyone not to bother. Unless the approach was a multidisciplinary perspective the result may inadequately produce the requirements expected by users of their experience.

User experience goes beyond a focus on requirements for task solution, final goals and achievements, but includes and encompasses other aspects, such as emotional, hedonic, aesthetic, affective and experiential variables. Few designers are incorporating these into requirements documents in order for developers to interpret and build. Today, user experience is becoming firmly placed in the context of use, action and reinforcement of that action to negatively or positively impact on the likelihood of future user and interaction. A number of models have been introduced to incorporate product characters beyond features. One in particular frequently referenced, Hassenzahl's (2003) model, incorporates character attributes for pragmatic and hedonic aspects with appeal, satisfaction and pleasure consequences. This assumes that each user assigns some attributes to a product or service when using it. Users experiences are different: some are able to use an application to perform their task while others simply are not. The interaction and response that a product elicits and provides depends on the individual user's experience with similar products. Users compare applications and have different expectations.

Conclusions

According to Gero, Kan, and Pourmohamadi (2011), most models of designing assume that designing is a process, rather than seeing design as some mysterious activity, and as a consequence, design cognition can be studied scientifically. The most commonly used method for studying design cognition is protocol analysis. In the late 1980s, Gero used his FBS scheme for decoding the process of designing engineered systems and for aiding designers in demystifying the design process. Although Gero has attempted to generalize FBS across design disciplines, it is important to note that to date there is not one but several functional representation schemes currently in the field. While the various functional representational schemes have many features in common, their ontologies often are quite different. Gero's research has continued to use the FBS ontology with new and different emerging design disciplines. This case study is the first case study of interaction design that has utilized this FBS schema and applied it to a design practice. Gero is using some of the data from the 125-Year project to compare it to another design practice studied at the same time as this study and this researcher agrees with him in that the FBS method is an appropriate method for studying the process of interaction design practice.

The interaction design discipline uses a variety of labels to categorize the design process as the designers and developers work through a problem for a user that ultimately delivers a solution that contributes to the advancement or betterment of a client's experience. A number of researchers connected to design research have used similar terms to group the tasks that occur during the process. For example, Zimmerman and Forlizzi (2008) use define, discover, synthesize, generate, refine and reflect to identify the different phases, while, Kan and Gero (2011) use formulation, synthesis, analysis, evaluation, documentation, and reformulation (I, II, III). These are similar descriptors for the process with the exception of the additional reformulation phases introduced by Kan and Gero (2011) that are an attempt to more accurately describe the creative and iterative way design actually happens.

Although always important to interaction design in practice, exploration and research, user experience is expanding in emphasis and definition. Fallman (2008) suggests interaction design has not yet commonly been defined; however, its nucleus stems from shaping digital artifacts—products, services and spaces—emphasizing the user experience. Much discussion has described the ingredients that formulate user experience—including physical, sensual, cognitive, emotional, and aesthetical issues:

> "…the relationship between form, function, and content; as well as fuzzy concepts such as fun and playability—a number of recent efforts have been made in the direction of establishing a better understanding of the role of the user experience in interactive systems design" (p. 4).

Organizations are beginning to pay more attention to research as research is becoming more attainable with search engine optimization driving a competitive advantage and metrics from GoogleAnalytics and WebTrends. Analysts and designers are better able to communicate what user experience success will look like and describe the concrete outcomes that stakeholders can measure next to the concrete outcomes they already understand from their existing processes. Techniques for communicating and demonstrating design impact are evolving and gaining acceptance as tangible, factual and measurable.

Forlizzi and Batterbee (2004) categorize three models for design practice: product-centered, user-centered and interaction-centered. Interaction-centered models explore the roles products serve in connecting the designer to the user. The authors present a framework that "…focuses on interactions between individuals and products and the experiences that result" (p. 262). Forlizzi and Batterbee (2004) assert what is needed is a framework that articulates experience in a way that does not rely on the point of view of any single discipline, but provides a common design-oriented frame of reference for all the relevant actors involved in design. Designers that are interviewed and observed recognize the importance of collaboration and multi-discipline team input to complete successful user experience projects.

In addition Gero (2010) states, "design creativity is not a unitary concept and needs to be treated multi-dimensionally by stating that design creativity may be in multiple locations" (p. 1), which is demonstrated in both conversations and observations made about the interaction design process. In this case study the interaction design process was documented and the collaborative process was observed. The design team appears to function in a similar way across projects. They use case-based reasoning, analogy and metaphor techniques and strategies to communicate, iterate and design their solutions. They leverage a variety of tools to provide insight into the process including: wireframes, mockups, requirements documents, use cases and others depending on the client and situation.

To answer the question of where design is in the production process this researcher has observed the process and applied a variety of FBS methodologies to understand the question as it relates to the team and the interaction design process. Gero (2010) urges researchers and designers to ask the question earlier in the stream by questioning, where does the creativity exist. Although this is a basic question it is difficult to answer. He suggests there are seven hypotheses candidate answers to this question "…in the: design; assessor of the design; design process that produced the design; designer; interaction between the user and the design; society in which the design sits; and interaction amongst all of the above" (p. 1). From the observations and results of this case study this researcher thinks it's all of the above, however much more work needs to be done on future projects to make more generalizations.

Many project processes and methodologies begin with requirements from the client. In many cases these requirements are gathered by analysts or project managers that do not possess design or development skills. In a non-user experience process, business, marketing, and technical needs are represented in design decisions, while the perspectives of actual users are completely absent. As a professional in user experience and interaction design this researcher has heard many comments from designers and developers that feel they are often brought to the conversation later than sooner and how it would have been helpful to participate in the process from the beginning. Based on the literature and data designer's have much to contribute and provide a variety of input that is helpful throughout the design process. However, the project benefits from a multi-discipline approach that is user informed and incorporates design at an early phase if not at the very beginning of the process. Zimmerman, Forlizzi and Evenson (2007) spoke with designers that "…described their early days of collaborating with HCI and software developers, where they were often brought in at the end of the process and asked to make the interface pretty" (p. 4). Furthermore, they described their attempts to improve the designs, frustrating because the suggestions they made could not be made because they came too late in the development process.

User experience research brings design and user perspectives into the process, completing the problem solving team. Gero (2010) states "design creativity research focuses on developing an understanding of the creativity of designs as a precursor to improving the generation of designs that are deemed to be creative" (p. 1). Design is not a linear process. According to Forlizzi and Batterbee (2004) to understand experience and the user experience that results from interacting with products, designers do situated research activities revolving around the interactions between people and products, and the experience that results. User experience design takes all the insights and skills of a design team. But what makes it user experience is focusing on the—context, activities, goals, and emotions.

To design for user experience is to design for the context of use. Awareness, desire knowledge, action and reinforcement are the context of use that either negatively or positively impacts the likelihood of future actions. A user's experience is more than visual design and content and is a reinforcing loop that goes beyond creating a desire to use a product or service. To achieve this experience organizations have to have a multi-disciplinary perspective in the teams' skill set likely utilizing some type of agile or iterative methods to adequately produce the base requirements expected by users of their experience.

Another question that this research pursued was what were the collaborative techniques, strategies and tools that were used in the design and development process. At the beginning of these projects the use of the design documentation artifacts interaction design teams use that act as communication methods and support the design process as design artifacts was not necessarily considered. Depending on the complexity of the system, the type of recipients, the activities and the contents determines the tools selected to do the support the process. There are tools for different aspects of designing: for design activities, the desired representation they produce, the recipients they are addressed to and the contents of the project they can convey. As previously mentioned there are in use a variety of tools: competitive analysis report, audience personas creative brief, content inventory, site map, flow diagram, and functional specification. Also utilized are: users stories, use cases, wireframes, database schema, experience prototype, design mock-ups, storyboards, templates, test plans, usability reports, heuristic evaluations, analysis reports, search engine optimization reporting and style guide. Projects do not use all of these tools unless the client pays to have them produced. The designer uses what is needed to complete the communication and arrive at the desired solution for all stakeholders. In these two projects the client confidence in the teams' ability to deliver their goal was relatively high and arriving quickly at mockup and design delivery was a strong indicator.

In 2007 Zimmerman, Forlizzi and Evenson (2007) interviewed a group of design professionals about design process and it's evolution. They encountered a few descriptions of the roles interaction designers bring to the process. First, they bring "…a process for engaging massively under-constrained problems that were difficult for traditional engineering approaches to address" (p. 4). Second, they bring a process of integrating ideas from art, design, science, and engineering, to make aesthetically functional interfaces. "One described this process as similar to composing music or conducting a symphony, where the job is to bring out the richness in a range of voices to make a singular thing" (p. 4). Third, designers believe they bring empathy for users to the process. Design is a uniformly followed process that does not vary significantly from project to project. As long as the client and intended user are continuing to be positively impacted and repeat usage, the uniformity of process appears to be working. Also, Zimmerman, Forlizzi and Evenson (2007) suggest that through an active process of ideating, iterating, and critiquing potential solutions, design researchers continually reframe the problem as they attempt to make the right thing" (p. 5). Further more, they describe the final output to be as "…a concrete problem framing and articulation of the preferred state, and a series of artifacts—models, prototypes, products, and documentation of the design process" (p. 5). Interaction designers provide an important perspective in the interaction design process.

As discussed earlier the process does not vary by individual on this particular interaction team. In general the designer's process has been generalized across disciplines to describe the phases to consist of some iterative mix of analysis, synthesis and evaluation and formulation. More projects are needed to evaluate the influence a designers role has on the outcome; however, design researchers have analyzed the novice to expert contribution and observed the cognitive process and indicate an expert can work more quickly through the design phases over a novice.

Although the data gathered does not supply information to improve the design process it does provide insight into the design process and how interaction design teams think and work together. Zimmerman and Forlizzi (2008) found in the research through design process "…initial theories take the form of an artifact" (p. 7). They suggest a research through design approach has other important outcomes; "…including reflection on new perspectives, extensible constructs, and systematic approaches to design and design research, often in the form of processes and design/research methods" (p. 7). They describe design artifacts as the currency of communication and for each of the pillars of design—education, research and practice—provide a connection and impact on their work.

Although design is often considered a phase in the process or a step before development, newer methodologies like agile for software development are iterative and demonstrating that design is threaded through the process and an indication that a better user experience is a result of incorporating design throughout the process. In addition, multiple design perspectives as demonstrated in these two projects provide validation, different personal experiences and different cognitive styles to ultimately generate more new ideas. Forlizzi and Battarbee (2004) posit,

> "Designers can offer a unique perspective on what kinds of user-product interactions and experiences a system might offer, and how these experiences might change over time. To do so, designers along with researchers need a deep understanding of those they are designing for" (p. 265).

Although there are still many unanswered questions about the user experience design process, protocol analysis was ideal for the two projects analyzed in this study and was rich in the applicability for use in future design projects. In these two projects the design team was involved from the very beginning of the process and the preliminary results indicate that design decisions about function and expected behavior began very early in the process.

There is much discussion about artifacts and the contribution they make to the discourse community. The process of sketching, refining and critiquing are not only the collaboration and iteration of the process, but they are the design patterns that are used as models and decisions for the community of practice. The artifacts document the process and the perspective of the designer tells the story of how the elements relate. Zimmerman and Forlizzi (2008) suggest "the challenge for the design research community is to connect the outcomes of research through design (the creation of the particular) with the focus in theory development (the creation of the universal)" (p. 6). The two cases in these projects that used the FBS ontology are not significant in the creation of the universal; however, they are support for understanding the process and the tools used to communicate the process, contribute to the knowledge of design, and support the communication and delivery of the design concepts to the client and the user.

Implications

As previously stated, FBS protocol analysis is ideally suited for studying the design process. The methods slice different perspectives of the cognitive design process and contribute to a better understanding of how designers work and ultimately this knowledge improves the products interaction designers deliver to clients and users.

Previous reference to the procedural issues of using linkographic analytic techniques has been made in this study. A level of expertise and skill was needed to subjectively segment the utterances into meaningful units that could be coded using the FBS ontology. In this study the segments of the design sessions varied and although the team members remained the same; the clients and approaches to the problem were different. After arbitration several iterations were needed to better understand the FBS coding for interaction design and each time the sessions were recoded several mistakes were found. Although the coding is time consuming, the automation of generating the linkograph with Linkographer 1.0 and the results the software generates makes applying protocol analysis to design extremely achievable.

The Delphi method or some other arbitration needs to be practiced. There are a number of studies that have not used arbitration for the coding because the coding of the utterances is subjective and it benefits greatly from the use of at least two coders and comparing their results against each other to build towards a consensus of the final coding before it is converted to a linkograph and analyzed.

Although a small portion of these two case-based projects discussed the artifacts used by the interaction design team, they are an extremely important documentation of the collaboration and design process in general. Much can be gained from closer examination of the tools used to communicate between team members and what they use to communicate and validate with the client.

Protocol studies are complex and difficult to design. One must take care in generalizing about the behaviors of any one designer or design team. Protocol studies require that subjects verbalize their thought processes. The process of analyzing design protocols is extremely labor intensive and time consuming. Despite these obstacles, protocol studies represent the best option for conducting research on design, design thinking and process. Together with the real life experience of designing and extensive field studies of design practitioners, protocol studies provide researchers with rich near actual opportunities to develop a more thorough understanding of design thinking and processes by directly observing designers in action.

Interaction design is experiencing a growing interest in the researching of the expanding relationship between the products functional features and benefits it provides and the customer's derived perception of the deliverables. This is reaching beyond functionality and usability to include what users actually experience in the way of a subjective, emotional and perceptive response. Hassenzahl (2003) describes an overview of a model that encompasses both the designer and user experience. The product elements include: features, content, presentation, functionality and interaction, chosen and combined by a designer possessing characteristics of pragmatic (manipulation) and hedonic attributes (stimulation, identification and evocation) with consequences for appeal, pleasure and satisfaction. The result is a user's personal reconstruction of the designer's intended product. Hassenzahl (2003) suggests that a starting point for anchoring design is to begin with people sharing a set of needs. Embedding the maximum amount of needs in the product results in a wider range of emotions. A usable and useful product—for example high-perceived fulfillment of manipulation needs—may lead to satisfaction if it accomplishes an important goal. In this way at least a part of the success is attributed to the product. To integrate theoretical, empirical, methodological and practical work is a unified and transformative approach to design work. Hassenzahl (2003) asserts one of the problems in design research is the failure to develop theory out of the observation of design practice and analysis of designed artifacts.

Implications for Design Practice

Methods of research are being applied to both academic and business practice to mediate and validate design decisions. Forlizzi and Batterbee (2004) suggest a consequence is the creation of new roles, such as user experience designer, user experience researcher, user experience modeler, in multidisciplinary teams and another outcome is the hybridization of research activities between members of the interactive design team. The roles, perspectives and experiences influence the solutions interaction teams utilize and their collective background and training prepares them for analysis and design of their artifacts.

According to Poggenpohl (2008) pertaining to graduate education in design, the apprentice-master pedagogical models of learning and the development of exclusively tacit knowledge are inadequate resources for preparing the next generation of high-level design practitioners or teachers. Today's design context requires more than formal aesthetic or technical skills; it requires the ability to operate critically in an ever-growing information environment, the global economy and within inter and multi-disciplinary teams. Interaction designers are using: user research (user personas, scenarios, etc.), goal-based user research (card sorts, focus groups, usability testing), and on-going user research (multivariate testing and goal tracking), to inform their work and expand their understanding of user expectations.

At least three factors are influencing changes in design practice: the sophistication of the user and their expectations on design; the advancement of the technology tools available to analyze their habits; and the artifacts being developed to measure and develop complicated multi-disciplinary teams perspectives into artifacts that are informed by a users’ context, activities, goals and emotions.

Although changes are taking place, these changes are not happening unilaterally. In a non-user experience process, marketing, business and technology needs drive design decisions and unfortunately to date the perspective of the actual user is absent from the design decisions. User experience process, artifacts and research bring the user's perspectives to the design process. Interaction and user experience designers are working to bridge more user research into design. This can be difficult, as clients do not always want to work through all the steps of process and often apply pressure to skip steps because they believe they understand the intended user enough to make decisions on their behalf. Through discovery, testing, and on-going user research interaction designers are better able to demonstrate measurable data and results to move beyond the perception of their role merely existing to make it look pretty and to communicate and demonstrate a cognitive process with artifacts like wireframes and usability reports to educate clients on data driven design decisions.

In addition the knowledge gained from user research and design practice through design artifacts and documents is rarely shared and usually left behind once the final product is delivered and adopted. Zimmerman, Evenson, and Forlizzi (2005) suggest there is knowledge to be gained from these discussions and critiques that influence the design of the final artifact. The knowledge and artifacts are rarely captured in a formal way for the benefit of others. They suggest the knowledge is possibly spread informally among the community, however, the lack of formality and publishing of this knowledge "…prevents designers from extending each other's work and from building a collection of shared discoveries" (p. 2). Zimmerman et al. (2005) suggest a parallel exists between the design process phases and the research knowledge production phases. Their parallel of process and research as presented in

Table 23 describe design phases and an opportunity for better understanding design practice and also suggest artifacts for research and knowledge production by phase. The knowledge opportunities illustrate the steps and techniques interaction designers utilize to advance the design decision-making process and are another signature of the cognitive effort. Typically these documents are used to provide a map or layout of the ideation. They are often in the form of an artifact used to convey a perspective to other team members and sometimes to the client. They are also an important document that demonstrates the knowledge and understanding the interaction team has about the goal and function of the application or interactive platform being developed. The interaction design process includes user research and contributes to research knowledge of the user that is valuable to the design community to formalize and advance design practice and process.

Table 23

Zimmerman et al. (2005) Knowledge opportunities in the design process

Project process by phase					
Define	Discover	Synthesize	Construct	Refine	Redirect
• team building • technical assessment • hypothesize	• contexts • benchmarking • user needs	• process maps • opportunity maps • frameworks • personas • scenarios	• features and functions • behavior • design language • interactions and flow models • collaborative design	• evaluation • scoping • interaction • specification	• post mortem • opportunity map • benchmarking • market acceptance
Research knowledge production by phase					
• prototypical user • prototypical user needs • client's needs	• user mental models • user process models • user's relation to context • summary of current products meeting needs (literature review)	• relationships needs of users, clients, and context • identify gaps (opportunities for new product or service)	• examples of process and flow models that users will and will not accept • insight into high-level guidelines for interaction • evaluation of widget performance and its relationship to software reuse • improved interaction flow models		• opportunities for improving design process • acceptance of design in the market place • new assessment of gaps (opportunities for new products and services)

Good design begins with good research. Interaction designers do not begin their process without some research or understanding of the user. Research bridges design. If the whole team does not have a grasp of the research findings, the knowledge gained will merely exist in a silo.

In addition to the process and research comparison, Zimmerman et al. (2005) discuss the importance of the different process and research phases and their contribution to the process. The discovery phase reveals the cognitive models users employ to meet their needs. The synthesis phase can lead to new product concepts, design projects and directions "…for technological development with documented market potential" (p. 9). Through interaction designer's use of complex artifacts—journey map, workflows, mental models, behavior matrix, isometric map, and tools—customer's needs are documented and are used for constructing the user experience. Artifacts are complex, both the ones used to arrive at the final product and the product itself. Outside of the design process, artifacts have a purpose that could be used to describe the innovation of the design process. The refine and construct phase also referred to by Kan and Gero (2009) as the reformulation phases are the core of the iterative design process. During the redirection phase, designers also generate artifacts that are opportunities for researchers to glean knowledge and are generalizable artifacts—post mortem and opportunity maps—that contribute to informing the community about the design process and a chance for team reflection.

Implications for Design Education

Researchers such as Gero (2010) Poggenpohl (2008), Zimmerman, Evenson, and Forlizzi (2005) and Zimmerman and Forlizzi (2008) are challenging design education to adopt a more critical and analytical approach to build research possibilities into the design field. Designers need precise descriptions of design actions as principles, theories and methods to transform design education into a learning strategy that produces the next generation of designers. To move comfortably between apprenticeship and experimental learning designers need skill in theory and practice. In the same way, design practice is driving a more reflective approach to the design process educating designers on design literacy "…referring to knowing the history, seminal writings and objects, practitioners and current controversies that establish continuity and change in design…." Reading Poggenpohl (2008) is an emerging curricular imperative. Poggenpohl suggests design is less about knowing the fleeting trends of design and more about understanding cultural shifts that drive design to re-evaluate and rethink the role and point of view of design.

Design practice and education can contribute to design research. Poggenpohl (2008) outlines four pillars that provide the framework for future of design education. They are discovery, integration, application and teaching:

- discovery is scientific and starts with what we do not know but what we think would be valuable to know;
- integration makes connections across disciplines and connects creativity to other professions so they can co-exist and compliment each other;
- application connects theory and practice together; and
- teaching to enrich the process of learning.

The four pillars respond to the increasing demand for predicting and explaining the consequences in design and generate new knowledge for the discourse community that moves beyond the individual experience to a more scientific, replicable, and generalizable research.

Researchers Poggenpohl (2008) and Zimmerman and Forlizzi (2008), propose a balanced approach to design education that teaches professional preparation and knowledge generation; integrating learning through doing, and not precluding thinking more deeply. It is important to dispel the myth that design is superficially present to make it look pretty and that the skills required are unknowable-intuition with some aesthetic gift. To transform a discipline that is slow to embrace scholarly information, starting with some simple questions, methodology and borrowing from other disciplines and applying and translating research into design action, will eventually build a design research culture and as a result enhance design performance.

Currently, designers add knowledge to the discourse community broadly, informally, and not necessarily with a deliberate intention of achieving a better result. Trade magazines or one or two designer's opinions are not necessarily adding to the field of design. Poggenpohl (2008) asserts research possibilities are expansive because the design field continues to be poorly defined.

Implications for Further Research

The design community is challenged for design research venues that produce proceedings. Zimmerman, Evenson, and Forlizzi suggest (2005) conferences and seminars as appropriate places for design research "…but since design conferences rarely produce written proceedings, the knowledge fades over time, forcing a process of constant re-discovery. Reaching a broad, multidisciplinary audience remains a challenge for this community" (p. 6-7). Poggenpohl (2008) asserts that little infrastructure exists nationally for peer review and research conferences to support design research.

The FBS ontology is an established scheme for analyzing the design process, however there are various other functional schemes that are in use. Although the frameworks have many features in common, as a consequence their ontologies are different. More comparisons need to be made to make this method generalizable for interaction design and design in general. Forlizzi and Battarbee (2004) suggest the results will be "…products and systems that improve the lives of those who use them" (p. 266). It is valuable for the future interaction designers to understand how people interact with products, other people and the resulting experiences and emotions that are manifested.

Gero's future directions for design creativity research (2010), he suggests many opportunities for design research that pertain to interaction design. They are organized in categories: design process; cognitive behavior; social interaction; cognitive neuroscience; measuring design creativity; and test suites of design tasks. In fact, more questions than answers exist. Creative designing process; interaction; users and cognitive behavior in Table 24 organize a small selection of questions that pertain to interaction design and these case studies.

Table 24

Research questions suggested by Gero (2010)

Creative Process	Interaction	Users	Cognitive Behavior
What are the processes? Can design by analogy be more useful? What are collaborative creative processes? What are team creative processes? What are the differences between a user designing and a designer designing? What is the effect of education has on these processes on performance and outcomes? What is the effect of experience of using these processes on performance and outcomes?	What are the effects of synchronous compared to asynchronous collaboration? What are the effects of co-location compared to remote location? What are the effects of the use of tools? What are the effects of asymmetry in the decision-making roles of the collaborators? How do team mental models develop? What are the process and outcome effects of changing team membership? What are the process and outcome effects of structured versus unstructured teams? How does expertise develop?	Do users customize differently to designers? Do users customize better designs than designers? Does user customization improve user satisfaction? What is the effect of interactions with the users of the design on the cognitive behavior involved in design creativity? What are design creativity measurement metrics for users?	What is the effect of interactions with other designers on the cognitive behavior involved in design creativity? What is the effect of interactions with the evolving design on the cognitive behavior involved in design creativity? What is the effect of education on the cognitive behavior involved in design creativity? What is the effect of experience on the cognitive behavior involved in design creativity? What are the cognitive behavior differences between a designer and a designer within a team?

Gero's research in design is expansive and the questions in Table 24 are not exhaustive in the opportunities that exist for contributing to closing the gaps in design research. Although research has been conducted in these areas, current studies of the creative designing process have produced results that have not been: 1) sufficiently robust (controlled experiments), 2) not generalizable (many were case studies), and 3) have been too narrow in scope, and not transferable (since different dimensions were used to collect and analyze the results) to generate adequate conclusions. Gero (2010) asserts future research in the cognitive behavior of design creativity must address these procedural issues. The results of this case study indicate FBS ontology is well suited for interaction design; however, more cases need to be analyzed to make the results generalizable.

Another significant opportunity is the rich amount of research that is possible with the creative work and process that occurs between incubation breaks and between design sessions. The documents and tools used to arrive at the aesthetic decisions and inform clients on the direction and decision-making. Zimmerman, Evenson, and Forlizzi (2005) describes these documents as offering the potential to extend the design system by recording the knowledge created during the process and assisting others in reproducing design results. Currently these client driven documents are not published, "…trapping the design knowledge in the participating designers and within a set of locked documents" (p. 6). The artifacts and documents used to arrive at the final artifact represent a more holistic and systematic depiction of the creative design process.

Interaction design, like all design disciplines pertains to the people, methods processes and artifacts. Fallman (2008) describes research issue activities as: 1) construction as a human activity (i.e., the study of how designers work, think, and carry out design activity, including the study of the methods and processes designers use); 2) functionality (i.e., how designed artifacts perform their jobs and how they work); 3) the study of the artifacts that are produced (i.e., how an artificial thing appears and what it means); and 4) an understanding in the context of an artifact. In the case of interaction design research, issues of aesthetics is more than how an artifact looks and feels, to include the aesthetics of the whole interaction: how the artifact works, how elegantly it is executed, how interaction flows, and how well the content fits in the context of the artifact and the user's experience.

Summary

This case study provided a unique opportunity to explore an interaction design team in practice collaboratively developing two design projects for the University of St. Thomas. The analysis and observation methods of this collaborative design experiment followed the (FBS) function behavior structure ontology, a well-established scheme for measuring the design process and cognitive behavior of designers across a variety of design disciplines. All six sessions were recorded and transcribed; FBS schema was coded and the Delphi method was used to arbitrate the final coding. This researcher performed the additional final coding after arbitration and the linkograph coding was imported into LINKOgrapher 1.0 for analysis.

This case study used issues, syntactic, and semantic distributions to measure the cognitive effort of the teams design process based on the linkographs generated by the LINKOgrapher software. Issues distribution analyzed the issues for the goal of changing a set of functions into design descriptions to describe the design process. Syntactic and semantic issue distribution measured the design process as transitional processes, as a closer to actual simulation of the actual process of designing. To attempt to predict the probability of a transitional state Markov chains were used and entropy was used to measure idea generation and consolidation or convergence.

The projects appeared to be similar in functional goals, but the client's intent was different. The tools used to evaluate the cognitive process revealed similarities in approach and artifacts leveraged (data and functional elements in the form of wireframes and requirements, taxonomies or information architecture and use cases), but their outcomes and solutions were different. Significant work is needed to better understand the subtleties of the design process and multi-discipline teamwork. The three distributions of issues, syntactic and semantic revealed the interaction design team works similarly with the use of case-based design and the use of analogies; their emphasis on behavior and structure is dominant. It is not conclusive that this is true for all interaction design projects, but it appears to be an important percentage of time that is spent when they are gathered together to collaborate, validate and build to consensus. The tools were not significant artifacts of study in this case study; however, their importance has been exposed.

The transitions (Markov model) of the different design phases are not generalizable across interaction design projects, but provide insight into the two cases analyzed to support the teams reliance on client information, user reaction, analogies and previous design patterns to form decisions and inform solutions.

The semantic and fixation results require more analysis to uncover findings that are meaningful. They are an indication that the team did fixate at times and stop generating new ideas and they are also an indication that the team did spend more cognitive effort in the behavior and structure phases of the ontology. It is not obvious that this was because of the types of projects that were analyzed or that this is typical of an interaction design team, but those are two possibilities.

Although much of the literature suggests designers do not have a strong appetite for research, interaction designers in practice perform a significant amount of research on their users and the user experience. The tools they leverage and produce demonstrate a significant amount of practice research that is involved in arriving at a solution for the client and the user. When designers are on the research team or in these UST case projects conducting them, the diversity of the questions and insights obtained from interactions with users increases substantially, leading to a very rich understanding of the problem. The way designers frame the research questions and interpret, or code, the answers already sets the stage for actionable results.

Design is inherently an iterative process; designers with sensitivity to user-centered processes not only expect to participate in the initial research, they expect to continue the process of research even as design artifacts are emerging. An important component of success in designing meaningful experiences is forming teams in environments that foster a culture of collaboration, creativity, and safe critique, and team thinking to move beyond the applications of today form a road of possibilities for the future.

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Appendix A

Appendix A (Detailed Description of Subjects)

	Title	Education	Professional Experience	Role
Bob	Interface Designer	B. A. Graphic Design	4 years	Design
Bill	Interface Designer	B. S. Visualization	4 years	Lead Design
Paul	Interface Designer	B. A. Photography	4 years	Design
Joe	Manager, Interface Systems	B. A. Business Administration & Economics	5 years	Creative Direction
Greg	Java Developer	No degree	9 years	Backend Flash
Tim	Java Developer	B. S. Computer Science	5 years	Lead Architect
Jon	Java Developer	B. S. Computer Science	2 years	Web Content Management
Sam	Java Developer	B. S. Computer Science	17 years	Developer
Jim	Java Developer	B. S. Computer Science & Masters of Science in Engineering	12 year	Developer

Diversity exists in age, where skills were obtained on the job versus formal training, and other related experience.

Appendix B Creative Design Brief

This document provides a brief description of the project. It outlines the objectives, audience, and assumptions for the project and details the creative concept the team intends to use moving forward. This document should accompany the materials for the Conceptual Design Review.

Viewbook Creative Brief

Project Details for

Date: 5/16/2009

Prepared by: **Phone:** **Email:**

Project name: Online Viewbook

Design Lead:

Project Lead:

Site Release: 9/15/2009

Project Concept

Undergraduate enrollment has proposed the creation of online version of their viewbook to create an online experience for prospective students and showcase university life and experience. The goal is to create an interactive media piece that is accessible online.

Objectives

The piece must be able to deliver media of the following types:

1. Text
2. Photos (Single & Slideshows)
3. Video
4. Links to content housed outside of the timeline

User Value Proposition / Benefits

This project's primary concern is to engage the following undergraduate student audiences:

5. Recruits
6. Prospects
7. Accepted

User Interface Considerations

While investigating the competitive landscape there was a lot of concern about how a printed piece could translate online and stand-alone.
The client will need to rethink the categories for content in the online version and group them differently for a better interactive experience.
The client also committed to limits in video so the updates can be made by their office to keep it dynamic and engaging.
They need to write new content for this specific audience and will be responsible for completing that prior to the launch date.

Assumptions and Research

No new logos should be designed for this piece.

125-Year Creative Brief

Project Details

Date: 9/16/2008

Prepared by: **Phone:** **Email:**

Project name: 125-Year Timeline

Design Lead:

Project Lead:

Site Release: 03/01/2009

Project Concept

University Relations, on behalf of Institutional Advancement, has proposed the creation of timeline to commemorate and showcase major University events that have taken place over the last 125 years. The goal is to create an interactive media piece that is accessible online.

Objectives

The piece must be able to deliver media of the following types:

8. Text
9. Photos (Single & Slideshows)
10. Video
11. Links to content housed outside of the timeline

User Value Proposition / Benefits

This project's primary concern is to engage the following audiences:

12. Current Student Education of past events/history
13. Alumni Engagement
14. Donor Engagement

User Interface Considerations

While investigating the competitive landscape there was a lot of concern about how a span of 125 years would be displayed because of the varying numbers of events in "the early years."

The client's problem that should be addressed through the design is that the first 15 years must be lumped as a "section" of the timeline. The rest of the sections had enough events to be divided evenly as 10-year sections.

The client also committed to never having more than 5 events in any one year. It is most probable that there will be between 1-3 events per year.

Additionally, it is a client goal to never have a decade with more than three eventless years.

Each decade or time-section needs an overview that is primarily text, but can also contain an image.

The 125th anniversary falls in 2010. The ability to append an extra section should be considered, as University Officials may want to add content to the timeline until the current Capital Campaign (Opening Doors) closes.

Assumptions and Research

No new logos should be designed for this piece.

Competitive Landscape

http://www.presidentialtimeline.org
http://100.biola.edu
http://www.bu.edu/law/timeline
http://www.valpo.edu/150/
http://www.hp.com/hpinfo/abouthp/histnfacts/timeline/
http://www.treasures.pitt.edu/history/timeline.html
http://www.circavie.com/timelines/
http://hondajet.honda.com/hondajetstory/timeline.aspx?bhcp=1
http://www.startribune.com/local/12166286.html

Appendix C Position Duty and Skills Descriptions

Interactive Designer	
1. Interaction design skills • Innovation and ethnography (studying behaviors, goals, attitudes, and motivations); • User modeling (creating personas and scenarios; creating empathy through role-playing); • Conceptual design (define product-level behavior and dialogue, principles and patterns); • Functional design (define function-level interaction principles and patterns); • Interface design (determine the initial set of visual, auditory, and tactile product "affordances"; layout, composition); • Information design (define how to present concepts and content); 2. Media design and development skills: • Screen/pixel-level design (including icons, palettes, typography, etc.); • Page design; • Animation; • Sound design; Rapid prototyping (paper, screen, and physical concepts);	3. Typical Software Tools: PhotoShop, Illustrator, Fireworks; Acrobat/Distiller; After Effects, Premiere; Director, Flash; Dreamweaver; Word, PowerPoint, Excel; Framemaker, Quark, Pagemaker; and Visio Skills and knowledge beyond Design: 4. Technical knowledge • Programming principles, tools, technologies; • Graphical User Interface development principles, tools, technologies; • Web development principles, tools, technologies; • Database principles, tools, technologies; Familiarity with the development process (specs, coding, testing, etc.); New and emerging technologies; Information or Interaction architecture (the area between systems diagram and user interface concepts).

Technical Process Analyst	
This position provides technical and programmatic leadership to the end user community by analyzing existing business, instructional and marketing operations and recommends and implements a technical solution. This position uses a variety of industry standard methods for project management, formal requirements gathering, instructional design, information design, use cases, structured testing and evaluation to ensure that projects delivered are sound (meeting the instructional, marketing or business goals) and are delivered in a timely manner. To qualify for the Instructional Analyst II position	1) **Serve as the project manager for enterprise software/application development or selection and implementation and other initiatives.** Communication or coordinate the communication between development team, departments, and third party vendors. Develop project plans (statement of work, and task lists). Task lists are maintained in project tracking tool. Work to maintain expectations of development team, departments, and third party vendors. Negotiate with vendors as appropriate. Conduct marketplace reviews/research regarding vendor, software, and instructional design research and or solution types. Write Request For Proposal

the candidate must have experience with many industry standard tools and methodologies regarding project management, system requirement development, system design development, and system testing and evaluation. In addition the IA II candidate must have experience in instructional and marketing process to be able to recommend and evaluate project's effectiveness. This person leads or serves on project teams and should have an intermediate to advanced level of knowledge and experience with all of these above mentioned processes and related tools; in addition this person must have a broad familiarity with multiple technologies and be an expert in a few. People may move up from an IA I position or with the adequate experience moved directly to the Instructional Analyst II position.	(RFP). End Result: Projects are successfully proposed, planned and executed in a timely manner. All parties have agreed to statement of work and scope is maintained. 2) **Develop formal requirements for enterprise software/application development or selection and implementation and other initiatives.** Conduct small Joint Application Development (JAD) sessions. Participate in large complex JAD sessions. Create Use Cases. Create Business Entity Relationship Diagrams or Unified Modeling Language (UML) Conceptual models, and data dictionaries. Document requirements to a testable and client sign-off. Conduct walkthroughs of the requirements. Review requirements written by others and provide useful critiques. End result: All parties have agreed and have knowledge of what is being built. 3) **Develop structured test, release and evaluation plans for software/application development or selection and implementation and other initiatives** Develop the test plan, test cases, design support structure, and execute the test cases as necessary. Coordinate testing efforts with end users. Tracking testing status and incidents found. Coordinate the change control effort. Created evaluation plan on application's effectiveness. End Result: application has no bugs, is fully supported, and information is gathered on effectiveness. 4) **Serve as an expert on a variety of technologies.** Serve as an expert consultant to departments or other IRT staff as needed on one or more, but not all of the following tools; Learning/Content/Assets Management technologies, such as Blackboard, Media development, such as Flash, Video/Audio, ASP, JSP, databases and database design, communications technologies such as, Breeze, streaming, chat. End result: Community can learn from expert. 5) **Consult on process improvement for instruction, administrative marketing needs.** Serve as the technical liaison to various departments at the University. Work with these areas to find ways to utilize their existing instructional/administrative/marketing process and recommend more effective systems. End result: Community learns from improved

	process. 6) **Is proficient with and follows IRT procedures** for Communication Updates, Call/incident tracking, Installation & Inventory, Knowledge Base, Communication guidelines. Remains current on information about customer communication and technology trends. Participates in professional development activities. Performs other duties as assigned.
Prefer B.A./B.S. required in Education, Instructional Design, Communication, Design, Rhetoric. Plus 2-4 years professional experience in education, web design, communications or related. Masters preferred. 1. Development of formal requirements. This should include interviewing skills, conducting JAD sessions, documenting current and desired workflow/interaction and logic and documenting requirements to a testable and understandable level. 2. Development of testing & evaluation plans. This includes writing test plans, writing test cases, executing test cases, tracking incidents, designing, writing, analyzing evaluation and coordinating change control. 3. Management of technical projects. This includes writing project plans (statement of work (SOW) and task list), working to maintain project scope, issue tracking and resolution. Experience with communicating to departments, development team, vendors, and management. Experience with a project-tracking tool. 4. Previous experience in a higher education/instruction institute is preferred but not required.	1. Excellent communication skills, both oral and written. 2. Conflict Resolution skills. 3. Instructional design/information design 4. Usability 5. Understanding of good process creation techniques. 6. Ability to work in a team/collaborative environment. 7. Ability to work with end users to develop custom solutions to their problems. 8. Critical thinking and analysis skills. Programming experience is desired but not required.
Developer	
Exists to perform senior level application design, development, quality assurance and implementation of enterprise applications of a complex nature used in conjunction with faculty, staff and student information. Ensures continuous application availability, accuracy and usefulness to hundreds of users. Applies technical expertise and knowledge of instructional/institutional processes to complete projects of undefined scope and assists management staff on very complex or large-scale projects. Provides project leadership skills with ability to	**1) Lead analyst for client business and technology requirements.** Meets with clients and or teams to gather requirements to ensure business needs and quality assurance is met. Applies technical expertise and knowledge of instructional and/or institutional processes to provide design and scope recommendations for both IRT management and client. **2) Lead designer, developer for implementation**

negotiate efforts in cross-functional and departmental teams. Work is performed under very general direction and within UST standards for programming, project management and quality assurance. This position has a wide degree of latitude and creativity and is responsible for carrying out complex assignments for which no clear precedent exists. This position requires expert level depth in multiple skill areas to maximize the University's investment in its web technologies and how they interact with the university's systems of record via undergraduate and graduate on-line applications, directory interfaces, databases queries and reports (to name a few) while focusing on customer service and satisfaction in a team-based environment.	**and quality assurance of software projects** Application design and development within business requirements, timeline and quality standards from pre-production to production and beyond. Implements production applications into our technical and support infrastructure. **3) Manages Enterprise Learning/Content/Asset Management Systems and Maintains Production Level Applications** This position has primary responsibility for the technical functioning of our Enterprise Learning Management System (Blackboard); leads Change Management efforts with our system administrator and Instructional Analyst staff; manages updates, upgrades and enhancements. Provides technical maintenance, troubleshooting, problem triage to existing applications to ensure 24x7 application availability. **4) Mentors less experienced staff and supports IRT procedures** Mentors less experienced staff and students; Is proficient with and follows IRT procedures for Communication Updates, Call/incident tracking, Installation & Inventory, Knowledge Base, Communication guidelines. Remains current on information about customer communication and technology trends. Participates in professional development activities. Performs other duties as assigned.
EDUCATION: BA/BS in MIS, computer sciences or related field and 4 years of professional experience, OR combination of education and experience to total 8 years. Masters preferred	Experience must include **most** of the following programming languages at an **expert level**: CFML, ASP, J2EE, J2SE, JSP, XML, DHTML, HTML, CSS, JavaScript, SQL, VBScript, ASP along with experience or formal training in using SQL Server/Oracle and relational databases. Experience with: UNIX, Sun Solaris 9, 10 or Linux, Windows and server technologies such as, Apache, Tomcat, IIS and Enterprise level Learning/Content/Asset Management and Portal technologies In addition to technical skills, Senior Application Developer must be able to manage multiple project /systems administration responsibilities and plan accordingly. Ability to substantially improve work processes. Proactively anticipates events well in advance of actions to ensure a successful outcome. Interact with clients, management and team members in an effective manner

	Interact with clients, management and team members in an effective manner. In addition to technical skills, Senior Application Developer must be able to manage multiple projects as well as administer enterprise web systems (learning, content, asset management and portal technologies). Must also possess ability to recommend improvements to existing technological environment and work processes and assist in establishing needed coding and development standards.

Additional skills today's all team members also need to possess are:

Communication skills:
Rhetoric/persuasive writing, Expository writing and composition, Technical writing, Public speaking/presenting.
Interpersonal skills:
Mediation & facilitation, Active listening, Interviewing, Team-building/collaboration.
Business skills:
Project management, Time management, Client management and Business writing (letters, email, meeting notes, summaries).

Appendix D

Consent Form

DESCRIBING THE INTERFACE DESIGN TEAM'S COLLABORATIVE DESIGN PROCESS USING PROTOCOL ANALYSIS

IRB # B08-049-3

You are invited to be in a research study that will observe the role of the designer and the meaning the designer contributes in shaping and establishing creative direction in a cross discipline collaborative process while working on a project. As part of your every day work, you step through a process with phases from analysis, design and development. Through the process, meaning is assigned to different steps and decisions. The study will observe the process of collaboration and negotiation that occurs between designer and developer to arrive at the resulting solution. You were selected as a possible participant because of your work on interface design projects at the University of St. Thomas. I ask that you read this form and ask any questions you may have before agreeing to be in the study.

This study is being conducted by: Elizabeth J. Houle, Web and Media Services, University of St. Thomas. This is in partial fulfillment of my Doctoral program at the University of Minnesota and not part of my responsibility at the University of St. Thomas.

The academic advisor for Elizabeth Houle is Barbara Martinson, Dept. of Design, Housing and Apparel, University of Minnesota. bmartins@umn.edu, 612-624-4239.

Background Information

The purpose of this study is:

1. To look at how the design process is performed and to analyze, through usability of the project produced, the effects it has on the outcome of the project.
2. To evaluate if design is a uniformly followed process and assess if it should or shouldn't be.
3. To assess at what point it is critical for the designer to be involved in the process. For example, are designers more often involved too early or too late?
4. To use observation and assessment to inform and improve the design process.
5. To observe and document what issues arise because of reliance on technology to complete the collaborative design work in recognition that the need to use technology to do our work is inevitable.

Procedures:

If you agree to be in this study, we would ask you to do the following things:
You will be asked to think aloud while talking through your process of creating an interface design artifact. You won't be asked any questions, but are expected to communicate as usual with your colleagues to gain information and decisions about the artifact. With your permission, the meetings will be video recorded and observed while you perform your every day work process. Protocol Analysis is the method I will be using to code the transcripts for analysis of the data collection about the process and about collaboration among you as team members.

The work process consists of two meetings and two hours of outside collaboration using a collaboration technology tool named Adobe Connect. This tool is already in use in the workplace. Two different projects will be executed. Together, these projects will require a minimum of 8 hours and maximum of 10 hours that will occur during your normal work ours.

Risks and Benefits of being in the Study

Although this research does occur at work the observation of your work during this study will not affect your work evaluations.

Compensation:

There will be no payment received for this research study.

Confidentiality:

The records of this study will be kept private on secure locked equipment. In the report to be published, I will not include any information that will make it possible to identify you as a subject. Research records will be stored securely and only researchers will have access to the records.
Only the primary investigator and the staff conducting the study will have access to the videotapes. They will only be used for the coding process and then they will be deleted.
This is a small sample size and although names will not be used, there is a possibility that you could be identified as having participated in the study.

Voluntary Nature of the Study:

Participation in this study is voluntary. Your decision whether or not to participate will not affect your current or future relations with the University of Minnesota or the University of St. Thomas. There will not be any negative consequences to declining to participate. Your Participation or not will not affect their relations with you or with their manager. Furthermore, it will not have any impact on their annual evaluations. If you decide to participate, you are free to not answer any question or withdraw at any time with out affecting those relationships.

Contacts and Questions:
Primary Investigator is Elizabeth J. Houle
Mail#5048, 2115 Summit Avenue, St. Paul, MN 55105-1096
651.962.6844
ejhoule@stthomas.edu

The staff conducting this study are: External Research Observer 1 and External Research Observer 2. You may ask any questions you have now. If you have questions later, **you are encouraged** to contact the External Research Observer 1, and External Research Observer 2.

The academic advisor for Elizabeth Houle is Barbara Martinson, Dept. of Design, Housing and Apparel, University of Minnesota. bmartins@umn.edu, 612-624-4239.

UST IRB Office, Mail: #5037
651-962-5341

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher(s), **you are encouraged** to contact the Research Subjects' Advocate Line, D528 Mayo, 420 Delaware St. Southeast, Minneapolis, Minnesota 55455; (612) 625-1650.

You will be given a copy of this information to keep for your records.

Statement of Consent:

I have read the above information. I have asked questions and have received answers. I consent to participate in the study.

Signature:____ Date: __________________

Signature of parent or guardian:_______________________ Date: __________________
(If minors are involved)

Signature of Investigator:_____________________________ Date: __________________

Appendix E

Syntactic Issue Distribution for Markov Model

Meeting 1

Syntactic 1st Order Markov Model

	R	F	Be	Bs	S	D
Requirement	0.53	0.07	0.07	0.00	0.20	0.13
Function	0.22	0.22	0.00	0.00	0.56	0.00
Expected Behavior	0.00	0.00	0.48	0.03	0.38	0.10
Structured Behavior	0.00	0.08	0.08	0.77	0.08	0.00
Structure	0.02	0.11	0.24	0.04	0.51	0.07
Description	0.21	0.00	0.11	0.00	0.11	0.58

Meeting 2

Syntactic 1st Order Markov Model

	R	F	Be	Bs	S	D
Requirement	0.33	0.08	0.25	0.00	0.25	0.08
Function	0.00	0.25	0.12	0.00	0.62	0.00
Expected Behavior	0.04	0.01	0.55	0.03	0.37	0.00
Structured Behavior	0.00	0.00	0.33	0.00	0.33	0.33
Structure	0.02	0.03	0.31	0.00	0.62	0.02
Description	0.00	0.00	0.50	0.00	0.50	0.00

Meeting 3

Syntactic 1st Order Markov Model

	R	F	Be	Bs	S	D
Requirement	0.00	0.00	0.00	0.00	0.00	0.00
Function	0.00	0.00	0.20	0.20	0.60	0.00
Expected Behavior	0.00	0.04	0.42	0.09	0.45	0.00
Structured Behavior	0.00	0.00	0.29	0.26	0.38	0.06
Structure	0.00	0.01	0.20	0.10	0.67	0.01
Description	0.00	0.00	0.40	0.20	0.20	0.20

Meeting 4

Syntactic 1st Order Markov Model

	R	F	Be	Bs	S	D
Requirement	0.47	0.38	0.12	0.00	0.03	0.00
Function	0.16	0.50	0.12	0.02	0.16	0.05
Expected Behavior	0.09	0.19	0.44	0.00	0.16	0.12
Structured Behavior	0.50	0.00	0.00	0.00	0.50	0.00
Structure	0.04	0.40	0.20	0.04	0.32	0.00
Description	0.15	0.15	0.15	0.00	0.08	0.46

Meeting 5

Syntactic 1st Order Markov Model

	R	F	Be	Bs	S	D
Requirement	0.25	0.00	0.00	0.00	0.75	0.00
Function	0.00	0.29	0.43	0.00	0.29	0.00
Expected Behavior	0.00	0.29	0.14	0.07	0.36	0.14
Structured Behavior	0.00	0.00	0.25	0.00	0.75	0.00
Structure	0.04	0.01	0.07	0.04	0.75	0.08
Description	0.00	0.00	0.30	0.00	0.50	0.20

Meeting 6

Syntactic 1st Order Markov Model

	R	F	Be	Bs	S	D
Requirement	0.14	0.00	0.00	0.00	0.86	0.00
Function	0.00	0.00	0.25	0.12	0.50	0.12
Expected Behavior	0.07	0.10	0.37	0.03	0.43	0.00
Structured Behavior	0.00	0.12	0.38	0.25	0.25	0.00
Structure	0.06	0.04	0.20	0.04	0.62	0.04
Description	0.00	0.00	0.10	0.10	0.20	0.60

Semantic Issue Distribution for Markov Model

Meeting 1

Semantic 1st Order Markov Model

	R	F	Be	Bs	S	D
Requirement	0.14	0.08	0.25	0.13	0.23	0.18
Function	0.02	0.09	0.34	0.32	0.22	0.00
Expected Behavior	0.04	0.00	0.46	0.10	0.34	0.06
Structured Behavior	0.00	0.06	0.02	0.92	0.00	0.00
Structure	0.00	0.07	0.26	0.14	0.53	0.00
Description	0.38	0.00	0.06	0.00	0.00	0.57

Meeting 2

Semantic 1st Order Markov Model

	R	F	Be	Bs	S	D
Requirement	0.02	0.00	0.42	0.00	0.56	0.00
Function	0.00	0.00	0.27	0.00	0.73	0.00
Expected Behavior	0.04	0.01	0.64	0.00	0.29	0.01
Structured Behavior	0.00	0.00	0.83	0.08	0.08	0.00
Structure	0.03	0.01	0.40	0.00	0.55	0.01
Description	0.00	0.00	0.68	0.00	0.27	0.05

Meeting 3

Semantic 1st Order Markov Model

	R	F	Be	Bs	S	D
Requirement	0.00	0.00	0.00	0.00	0.00	0.00
Function	0.00	0.10	0.39	0.20	0.29	0.02
Expected Behavior	0.00	0.02	0.55	0.16	0.26	0.01
Structured Behavior	0.00	0.00	0.25	0.47	0.25	0.03
Structure	0.00	0.01	0.22	0.16	0.61	0.01
Description	0.00	0.00	0.07	0.36	0.50	0.07

Meeting 4

Semantic 1st Order Markov Model

	R	F	Be	Bs	S	D
Requirement	0.17	0.34	0.23	0.00	0.15	0.11
Function	0.14	0.33	0.25	0.00	0.14	0.14
Expected Behavior	0.08	0.32	0.28	0.00	0.13	0.18
Structured Behavior	0.10	0.28	0.30	0.01	0.19	0.12
Structure	0.14	0.32	0.26	0.01	0.14	0.13
Description	0.10	0.32	0.28	0.00	0.13	0.17

Meeting 5

Semantic 1st Order Markov Model

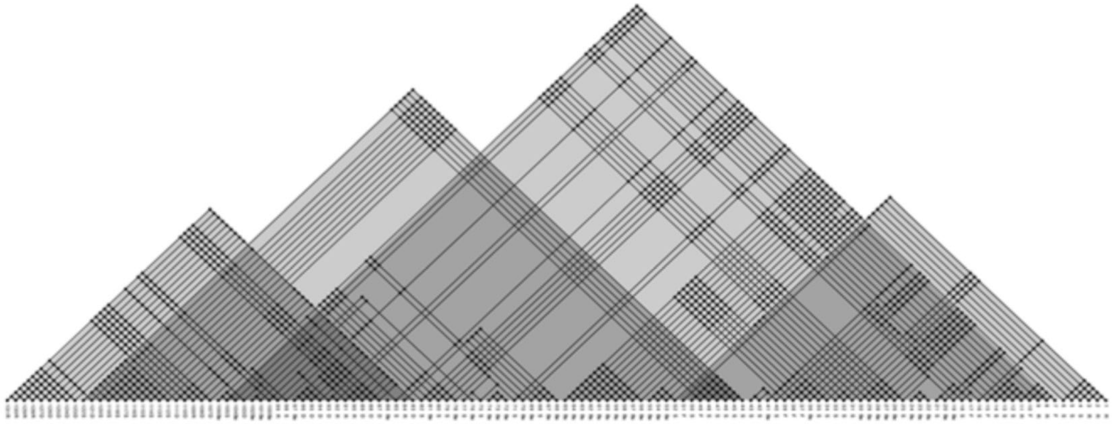
	R	F	Be	Bs	S	D
Requirement	0.04	0.01	0.01	0.00	0.94	0.00
Function	0.07	0.20	0.31	0.04	0.27	0.11
Expected Behavior	0.06	0.15	0.17	0.05	0.50	0.07
Structured Behavior	0.08	0.20	0.26	0.04	0.34	0.08
Structure	0.06	0.01	0.02	0.00	0.90	0.01
Description	0.06	0.02	0.04	0.01	0.84	0.04

Meeting 6

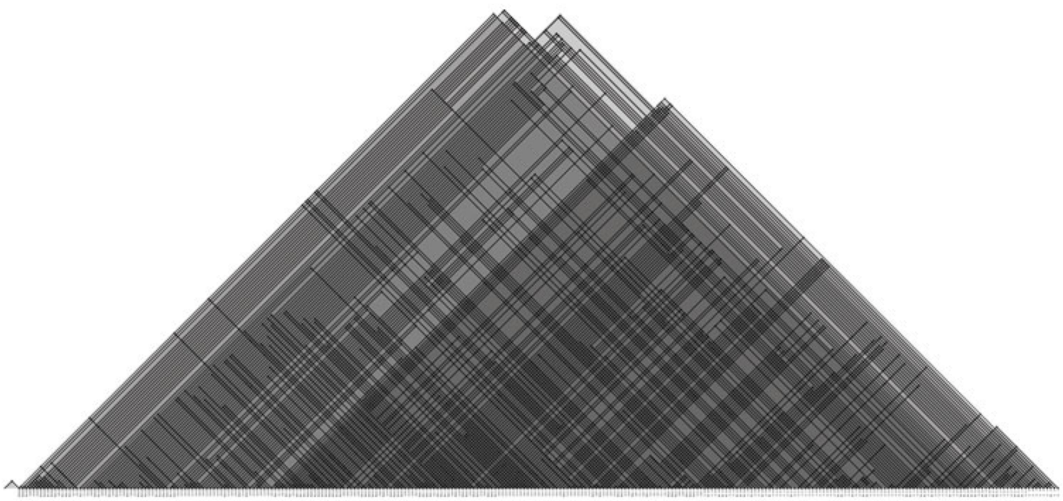
Semantic 1st Order Markov Model

	R	F	Be	Bs	S	D
Requirement	0.12	0.00	0.19	0.08	0.56	0.05
Function	0.10	0.07	0.30	0.13	0.37	0.03
Expected Behavior	0.07	0.02	0.24	0.10	0.54	0.02
Structured Behavior	0.21	0.00	0.25	0.13	0.37	0.04
Structure	0.08	0.08	0.24	0.09	0.50	0.01
Description	0.04	0.04	0.25	0.06	0.56	0.06

Appendix F Linkographs



125-Year session 1



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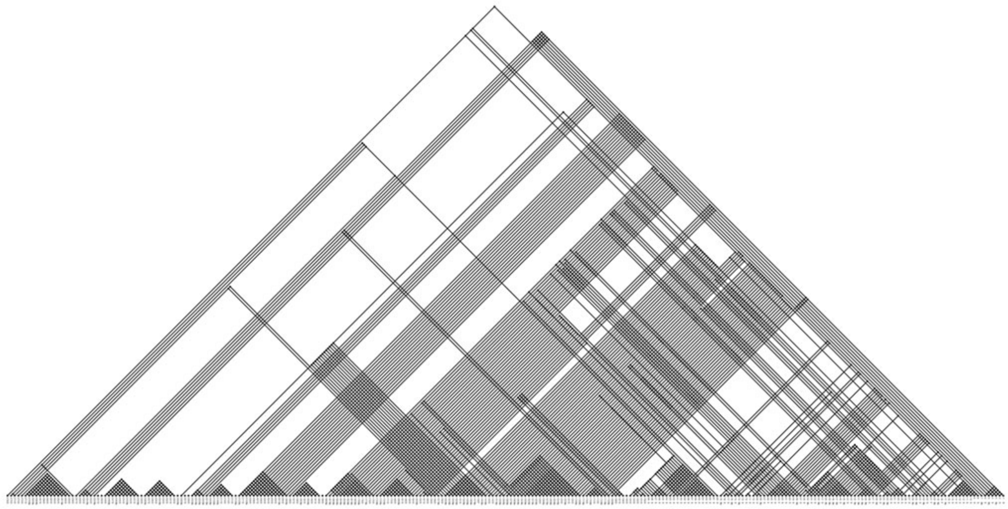
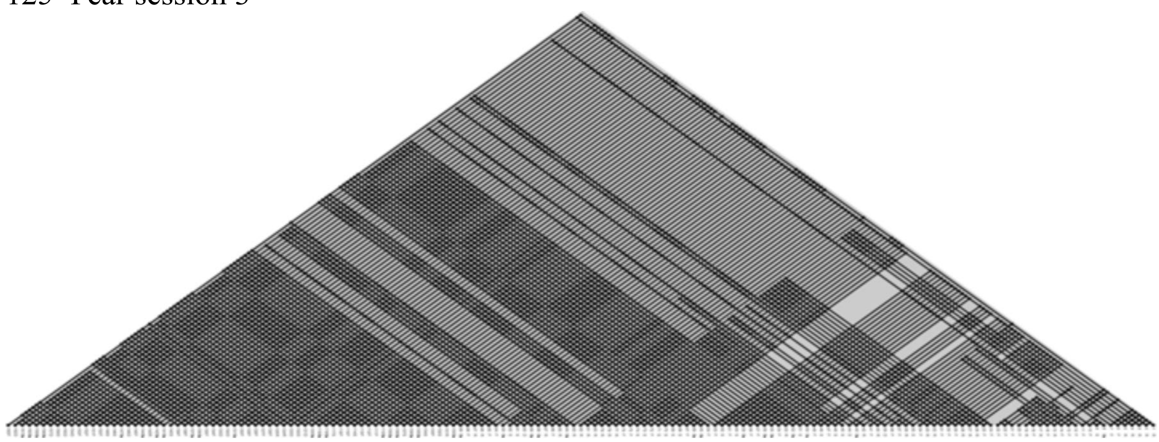
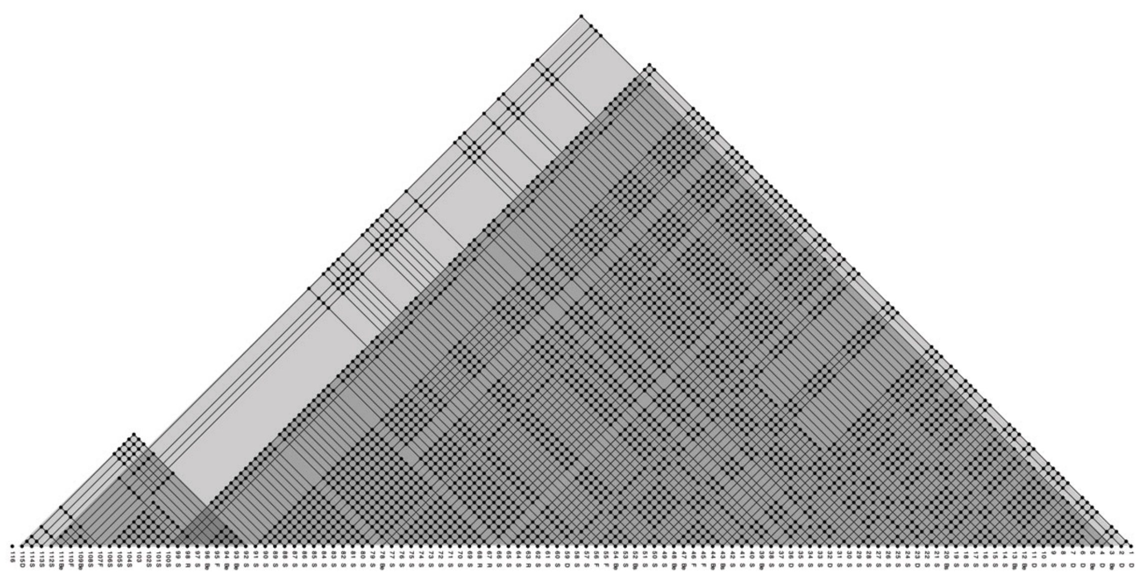


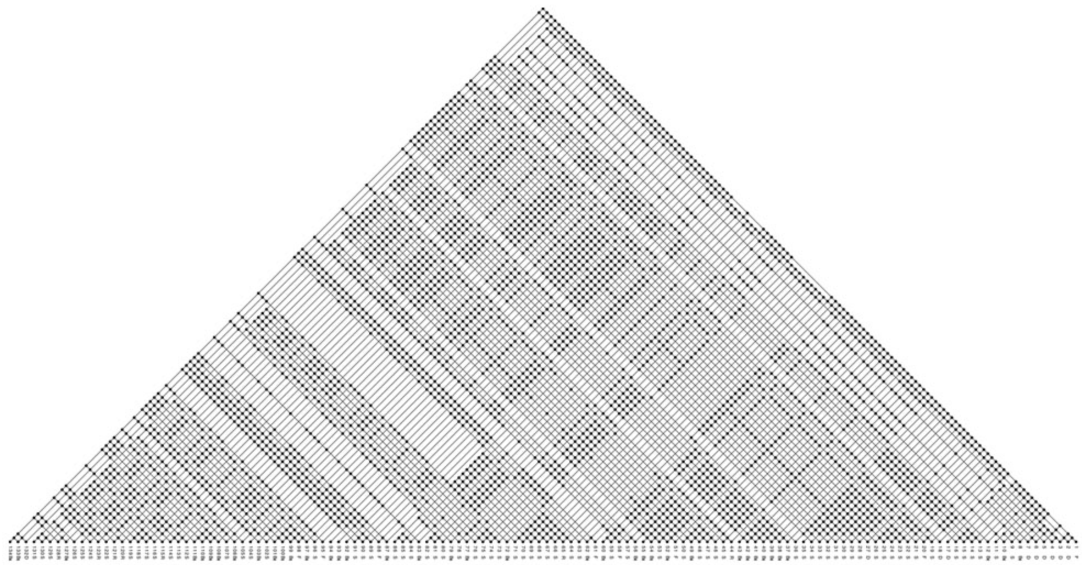
125-Year session 3



Viewbook session 1



Viewbook session 2



Viewbook session 3