

The Storytelling + Design Framework: Design Guidance for the Concept Phase of Medical Device Design

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Dissertation submitted to the faculty of the Virginia Polytechnic Institute and State
University in partial fulfillment of the requirements for the degree of

Doctor of Philosophy
In
Industrial and Systems Engineering

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May 25, 2012
Blacksburg, Virginia

Keywords: narrative inquiry, needs analysis, knowledge elicitation

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ABSTRACT

The National Institute for Occupational Safety and Health's (NIOSH) "Prevention through Design" (PtD) initiative encourages the exploration of different methods to foster dialogue between engineers and healthcare workers. Although engineers are encouraged to follow a user-centered design (UCD) process to identify user needs (ANSI/AAMI, 2009; IEC, 2007), NORA (2009) warns that engineers may "fail to get the full range of healthcare worker input on the usability of a device". The primary goal of this research was to present storytelling as an elicitation method that addressed the PtD call for methods that improve usability within healthcare.

This work provides three contributions to the PtD initiative. First, a conceptual model for the role of storytelling in design, which represents a synthesis of narrative and design research, is presented. The conceptual model explicitly states how the elicitation and analysis of stories results in the identification of a design opportunity that addresses user needs. Second, the Design + Storytelling framework, which guides designers' use of storytelling, is presented. An instantiation of the framework specific to the identification of a design opportunity within an emergency room (ER) is investigated to determine the framework's impact on design. Findings resulted in the study's third contribution: design guidance comprised of storytelling guidelines, decision support tools for storytelling method selection, and traceability support for design evaluation.

The investigation of the framework focused on two primary stages: (1) story elicitation and (2) story analysis. Storytelling sessions, which varied in context, collected 573 stories (i.e., 441 habitual, 132 hypothetical) from 28 ER nurses. Qualitative analysts used the framework's instructions to identify and specify 383 user needs within the narratives. Empirical comparisons of the compiled needs across groups informed decision rules for elicitation method selection. The impact of the framework's analysis instructions during design practice was investigated. Student design teams analyzed nurses' safety stories to create a conceptual design for an identified design opportunity. Findings indicated a trend for stakeholder experts to rank conceptual designs created by teams with the instructions as more usable than teams without the framework's instructions. The theoretical and practical exploration indicated a positive impact on design.

ACKNOWLEDGEMENTS

My interest in storytelling stems from a childhood spent with two grandmothers who simply would not shut up. As the majority of Grammy Carlson's tales are unsuitable for print, I will simply thank her for teaching me the art of storytelling.

Although I cherish Grammy's myriad of stories, my favorite story hails from Grandma Wanda's childhood adventures. A child of Polish & Lithuanian immigrants, Wanda grew up in urban Belleville, NJ during the 1930s. An annual Halloween tradition was to visit the home of a prominent "scientist" who offered an atypical treat. In lieu of a candy bowl, he placed a cauldron filled with water on his porch. As trick-or-treaters peered into the cauldron, they spotted shiny new dimes ready for the taking; however, as children reached in to grab the spoils, they quickly realized that the cauldron was electrified.

"ZAP! ZAP! ZAP! We could never get those dimes no matter how hard we tried," Grandma Wanda explained. "We even developed strategies. We tried going in as fast as we could. We could never beat the ZAP! Once we even got a whole group of us kids to hold onto the cauldron together while one of us went in for the dimes. We thought we could distribute the pain amongst us, but that didn't work either."

"Wait," I asked, "You said this was an annual tradition? You did this more than once? Why would you allow yourself to get electrocuted repeatedly by some maniac?"

"Dimes, Kimmy! In the Great Depression! We had to try!"

When Grandma Wanda shared this story with me last year it resonated my own feelings of academia and research. I had a successful industry career, but further advancement was limited by my education. I was unchallenged and unhappy. ***I had to try.*** I would like to acknowledge the following people for holding onto the cauldron as I dove in after those sparkling dimes:

Thank you, Dr. Maury Nussbaum for changing my career in a 15-minute conversation. I initially met with you as a formality to change my part-time master's status to non-thesis and I left with funding for a full-time doctorate. This research was supported by Grant Number T01OH008613 from CDC-NIOSH.

Thank you, Dr. Woodrow Winchester III for acting as my advisor and for helping me shape this work. When I reflect on where I was, both personally and professionally,

when we first started to discuss storytelling in 2007, I realize how much your influence has changed me and how subtle and difficult your job is as an advisor. Also, thank you for comparing me to the movie star Kristen Bell, even though your reference was to a scene in which she fell into a punch bowl. I must admit I see the resemblance too.

Thank you, Dr. James D. (Sean) Arthur, for your honest and critical feedback. During one meeting about a rejected CHI paper, you told me that I wrote like someone with low self-esteem and that I needed to “write like a Ninja!” while you mimed karate moves. That was the most ridiculous, yet most useful, dissertation advice I’ve received.

Thank you, Dr. Tonya Smith-Jackson for your infectious laughter. On several days where I’ve felt overwhelmed in my office I’ve been buoyed by the chuckles emanating from your office. Your laughter reminds me that while research is hard, it’s also fun.

Thank you, Dr. Brian Kleiner for helping to diminish any biases I had towards undergraduate students. As your office is next-door to mine, I’ve witnessed how your expression shifts to delighted surprise when you realize you have 10-15 undergraduates waiting outside your door. Your mentorship of undergraduate students inspired me to advise some undergraduate research projects relating to this work.

I would also like to extend my deepest appreciation to the hospitals, ER department managers and nurses who facilitated this study. Also, thanks to the student designers who developed innovative solutions to address ER problems and the stakeholder experts who volunteered time to critique students’ work.

I would also like to thank the students that performed the qualitative analyses required for this work. Thanks to the graduate students that volunteered their time for this study: Sudipto Aich, Shvetha Soundararajan, Julee Harlow, Stephanie Alpert, Yushi Yang, Shreya Kothaneth, and Kyunghui Oh. Thanks to the undergraduate students that performed analyses as part of undergraduate research: Zhouhua Zhang, Tian Xia, Varsha Doggala, Saba Sadeq, Derek Ho, Chun Wang, Erin Folly, Alan Torrico, Jodeen Johnson, Deborah Parker and Dominique Piggott. Thanks to Nels Johnson for his guidance for the statistical analyses.

I have also benefited from the incredible community of HFES and HCI students. I would like to thank Enid Montague, Brad Davis, Aubrey Baker, Jay Clasing, Leanna

Horton, Bobby Beaton, Laurian Vega, Dee Miller, Na Mi, Harry Kim, Yoon Lee, Yu-Hsui Hung and Ralph Cullen for their encouragement. Also, thanks to Dr. Hartson and Dr. Pardha Pyla for teaching an amazing Usability Engineering course during which I thought, “I want to be like you one day.”

And, of course, thanks to my family. Thank you, Dad, for valuing your children based on who they are and not by their accomplishments. Parents can provide children no greater freedom than the ability to fail spectacularly. Thanks to my brothers, Steve and Doug, for allowing me to Facebook stalk them during study breaks. Thanks to Jeffra for offering to send me a spill-proof cup when I confessed that I spilled margarita all over my new laptop. Thanks to Aunt Kathy and Uncle Lenny for simply being awesome. Thanks to my husband, Shawn, for building me the desk on which I wrote this dissertation. Thanks to Mom for her beaming smile of pride throughout my childhood. Sometimes I worry that people see my fabulous life and assume that your loss has not affected me, so I would like to take this opportunity to explicitly state that I think about you everyday and I miss you terribly. Sure, it would probably be a greater testament to the impact of early-onset Alzheimer’s disease if I became a meth-head prostitute instead of a Doctor of Philosophy, but we both know I lack the required social skills. Thank God for that.

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CHAPTER 1. INTRODUCTION

1.1 Problem statement

The Institute of Industrial Engineers (IIE) Council of Fellows identified the reengineering of healthcare delivery as a grand challenge facing engineers today (IIE, 2007). Part of the challenge in reengineering healthcare delivery is the design of usable medical devices. Medical device usability directly impacts the practitioner's ability to perform diagnostic tasks in an effective, efficient, and safe manner often resulting in medical error. A device with poor usability may frustrate the practitioner, increasing her/his stress level in a notoriously high-stress and complex work environment. In addition, a device with poor usability may facilitate practitioner error, increasing the patient's risk of injury and undermining patient safety. Practitioners may become "second victims" of patient injury from the emotional and professional consequences suffered as a result of the error (Wu, 2000).

The 2009 National Occupational Research Agenda (NORA) also identifies the design of medical device interfaces as a Prevention through Design (PtD) research gap due the impact of usability on practitioner and patient safety. Although designers are encouraged to follow a user-centered design (UCD) process to identify user needs, NORA (2009) warns that designers may "fail to get the full range of healthcare worker input on the usability of a device." One barrier to designers' understanding of usability needs is the lack of communication between designers and practitioners. The primary goal of this research was to present storytelling as a knowledge elicitation method that addressed the PtD call for methods that improve usability within healthcare.

1.2 Motivation

Previous work (Gausepohl, Winchester, Arthur, & Smith-Jackson, 2011) explored storytelling's efficacy as an elicitation method for medical device usability requirements through comparisons of information elicited from infusion pump nurses from two methods: (1) focus groups followed by individual interviews (FG&I) and (2) focus groups followed by individual storytelling sessions (FG&S). FG&S participants contributed significantly more distinct context-of-use information, with an emphasis on social context. These findings suggest that storytelling aids designers' understanding of usability requirements. PtD contributions of this work include a

protocol for conducting a storytelling session and a framework for defining usability requirements within the healthcare domain.

The opportunity to provide additional PtD contributions through further explorations of storytelling's use in design motivated this work. Given the criticality of the conceptual design phase, this research aimed to provide medical device designers with necessary guidance in how to overcome obstacles to conducting user research in the healthcare domain. Although medical device standards (ANSI/AAMI, 2009; IEC, 2007) emphasize the importance of user research due to its impact throughout the design cycle, several barriers impede the success of traditional user research approaches. Domain specific barriers, such as institutional review board (IRB) and health insurance portability and accountability act (HIPAA) constraints, limit the ethnographic methods available to designers (Martin, Murphy, Crowe, & Norris, 2006; Martin, Norris, Murphy, & Crowe, 2008). An additional barrier within all domains is the lack of methods to analyze and represent data gleaned from contextual analysis (Pyla, Hartson, & Judge, 2010).

1.2.1 Medication errors as a healthcare challenge

Medication errors are one of the most common types of healthcare errors. Devices, such as the infusion pump, improve safety by introducing controls that regulate a patient's intravenous fluid or medication intake. However, when used as intended, the design of infusion pumps may not sufficiently mitigate many administration errors, such as delivering the wrong medication or programming an incorrect volume or rate (Husch et al., 2005). In fact, the design of the infusion pump may actually facilitate operator error (Dain, 2002; Kunac & Reith, 2005; Lane, Stanton, & Harrison, 2006). For example, a mere "slip of the finger error" can result in the entry of an incorrect rate that delivers either an under- or overdose of medication to the patient (Husch et al., 2005). Under-dosing leads to negative patient outcomes when the patient is denied therapeutic medication, such as antibiotics to treat an infection. Overdosing is particularly problematic for "high-risk" drugs, which have low error tolerances that may result in patient death if exceeded (Nuckols et al., 2007).

Errors in the requirements stage have a cumulative effect throughout the design process and result in correctable, uncorrectable, and hidden error in the final product (Davis, 1993). Hidden errors are a particular threat to safety as they may not be exposed during testing and may

only be discovered after a sentinel event has occurred. An analysis of FDA recalls reveals that a shocking one-third of all medical device designs with a software component have been recalled (Bliznakov, Mitalas, & Pallikarakis, 2007). In addition, design problems have been identified as a contributing factor to 44% of FDA medical device recalls (Story, 2007).

1.2.2 Designing usability to address medical errors

An infusion pump interface should be designed to prevent practitioners from incorrectly entering the medication volume as the rate. A human factors strategy to reduce medical error is to “design out” device characteristics that contribute to error (Purcell, 2007). Design standards recommend a focus on usability to facilitate the removal of these error opportunities. IEC 62366 (2007), the standard for the application of usability engineering to medical devices, suggests that designers create a usability specification during design and identifies potential hazards and errors associated with usability. Device usability is validated against testable requirements listed in the specification to ensure the design reduces opportunity for error. Usability testing also ensures that additional hazards have not been introduced as a result of the new design.

1.2.3 User-Centered Design (UCD): How usability is achieved in design

To encourage designer focus on usability, design standards recommend a user-centered design (UCD) process. UCD begins with gaining an understanding of the context in which a medical device is to be used. Design standards recommend the use of ethnographic methods, such as observation, interviews, and focus groups to gain an understanding of practitioner needs during the concept stage of design. Unfortunately, medical device designers must overcome domain specific obstacles to utilize these recommended methods throughout the entire design process (Martin et al., 2006; Martin et al., 2008; Ward & Clarkson, 2007). For instance, although standards require that designers include user research techniques during requirements gathering, patient privacy standards often prevent designers from observing practitioners in context. In lieu of direct observations, designers may elicit requirements using self-report methods. However, important contextual information is lost during self-report since the practitioner is removed from the environment and must retrieve, recall, and express the

information in a way that is understandable to the designer. The inability to observe practitioners in a realistic work environment coupled with the limitations of traditional self-report methods impede understanding of the context in which the device is to be used.

1.2.4 Deploying UCD: Gaining context-of-use understanding

Most formal definitions of usability define this contextual component as the “context-of-use”. ISO 13407 (1999), the standard for human-centered design processes for interactive systems, provides a general definition of context-of-use as the “user characteristics, tasks, equipment, and a physical and social environment in which a product is used.” IEC 62366 (2007) warns designers that usability is impacted by the context-of-use. For example, an infusion pump originally designed for use within a hospital ward may be viewed as too bulky for use within a crowded ambulance. Since designers must understand the context-of-use to ensure product usability, further exploration into alternative methods for eliciting appropriate requirements is needed in the healthcare domain. The importance of context-of-use understanding is important considering the unique characteristics of the healthcare domain. For example, device usability may affect safety and health of both practitioner(s) and patient(s), which makes usability both an Occupational Safety and Health Administration (OSHA) issue and patient safety concern. Improved understanding of the context-of-use also has the potential to support other NORA PtD initiatives within the construction, manufacturing, and agriculture domains, which may be explored in future work (See Section 7.1).

1.2.5 Storytelling: A potential ethnographic method for designers

Storytelling has been used successfully as an ethnographic research method for both data gathering and analysis within the social sciences (Mishler, 1986; Riessman, 1993). Specific to healthcare, storytelling has also facilitated data gathering and analysis exercises. For example, storytelling has been used to collect nurses’ narratives in an attempt to understand how healthcare workers resolve ethical dilemmas in the workplace (Wolf & Zuzelo, 2006).

Narratives are an essential component of the storytelling method. In its simplest definition, a narrative is a personal account of experience; however, a universal narrative definition is lacking in the literature. For example, narrative can be viewed as a sequential ordering of events with a

specific structure (Labov & Waletzky, 1967), as a representation of character and action (Riessman, 1993) or as a joint production of storyteller and listener (Mishler, 1986).

Since designers have adapted other ethnographic methods for use during user needs analysis, the efficacy of storytelling during requirements gathering warrants further investigation. In contrast to interviews, which encourage a question and answer discourse, storytelling encourages the elicitation of a personal narrative of experience. Although it is possible to elicit stories during interviews, it requires an adept interviewer who asks the “right” questions and provides freedom of response through the use of long pauses (Riessman, 1993). One of storytelling’s potential benefits as an elicitation method during user requirements gathering is the ability to elicit narratives that reveal practitioners’ experiences embedded within contextual information that may be lacking in interview responses.

1.3 Goals

In an effort to provide additional PtD contributions in healthcare, this research had the following goals:

- (1) Develop a conceptual model for the role of storytelling in design
- (2) Develop a framework (i.e., Design + Storytelling framework) that guides designers’ use of storytelling as a knowledge elicitation method
- (3) Provide practical design guidance informed by empirical findings from the framework’s application

1.4 Research questions & hypotheses

The study's research questions were created to support the goals of the project identified in Section 1.3. The overall guiding research question explored, "How does the Design + Storytelling framework impact design?" Since the success of an elicitation method is dependent upon (1) the ability to elicit desired information and (2) the ability to analyze collected information, the following research questions explored both aspects of the Design + Storytelling framework.

(RQ1): What is the impact of the framework's elicitation methods on design?

RQ1a: What is the impact of storytelling session context (i.e., setting, questions) on the user needs elicited?

(RQ2): What is the impact of the framework's analysis guidance on design?

RQ2a: What is the impact of the framework's analysis instructions on designers' ability to identify user needs?

RQ2b: What is the impact of the framework's analysis instructions on designers' ability to identify a design opportunity?

The following hypotheses were tested to address the identified research questions:

H1: Group storytelling sessions (i.e., Method GHH, Method GH) will elicit more usability needs than individual storytelling sessions (i.e., Method IHH, Method IH).

H2: Habitual & hypothetical prompts (i.e., Method GHH, IHH) will elicit more usability needs than habitual prompts (i.e., Method GH, IH).

H3: Design teams following the framework's analysis instructions (i.e., W teams) will identify more usability needs than design teams without benefit of the framework's instructions (i.e., WO teams).

H4: Stakeholder experts will critique conceptual designs created by teams following the framework's analysis instructions (i.e. W teams) as higher in quality than design teams without benefit of the framework's instructions (i.e., WO teams).

1.5 Approach

The research was conducted in three phases (Figure 1). In the first phase stories were collected from 29 ER nurses. Three teams of narrative analysts analyzed 22 storytelling transcripts to form stories into narratives, which resulted in the creation of 22 narrative transcripts. In Phase 2 one thematic analysis team analyzed the 22 narrative transcripts to identify the ideal set of user needs. RQ1 was addressed in Phase 2; the ideal user need set was used to test hypotheses H1 and H2. Student design teams in Phase 3 identified user needs from a subset of the 22 storytelling transcripts and created a conceptual design that documented the team's identified design opportunity. RQ2 was addressed in Phase 3; user need lists within students' projects were compared to address hypothesis H3. In addition, stakeholder critiques of projects were used to test hypothesis H4.

class lab exercises coupled with out-of-class assignments. Safety stories were chosen due to the PtD focus of the research. As part of lab exercises student design teams:

- (1) specified identified functional needs
- (2) specified identified usability needs
- (3) identified a design opportunity informed by identified needs and
- (4) created a conceptual design for the chosen design opportunity.

The framework's impact on design product was explored via stakeholder experts' evaluation of students' projects.

Table 1 provides an overview of the research phases, research questions, and hypotheses explored during the course of this research.

Table 1. Research overview

| Phase | 1. Elicitation of ER Nurses' Stories | | 2. Identification of User Needs | 3. Framework in Practice | |
|--------------------------|--|---|--|--|---|
| Method | Storytelling | Structural Analysis | Thematic Analysis | Design + Storytelling framework | Questionnaires |
| Research Question | | | <ul style="list-style-type: none"> •RQ1a: What is the impact of storytelling session context on the user needs elicited? | <ul style="list-style-type: none"> •RQ2a: What is the impact of the framework's analysis instructions on designers' ability to identify user needs? •RQ2b: What is the impact of the framework's analysis instructions on designers' ability to identify a design opportunity? | |
| Hypotheses | | | <ul style="list-style-type: none"> •H1: Group sessions will elicit more usability needs than individual sessions •H2: Habitual & hypothetical prompts will elicit more usability needs than habitual prompts | H3: W teams will identify more usability needs than WO teams | H4: Stakeholder experts will critique W teams' conceptual designs as higher in quality than WO team's designs |
| Purpose | Obtain data set for Phase 1 and Phase 2 | Prepare data set for Phase 2 | Identify the ideal user need set | Evaluate the efficacy of the framework's analysis instructions during a design task (i.e., process) | Evaluate the efficacy of the framework's analysis instructions during a design task (i.e., product) |
| Activity | <ul style="list-style-type: none"> •Developed storytelling protocols •Obtained hospital IRB approval •Conducted storytelling sessions | <ul style="list-style-type: none"> •Developed analysis protocols •Trained analysts •Assessed inter-coder reliability | <ul style="list-style-type: none"> •Developed grammar rules for the specification of user needs •Developed analysis protocols •Trained analysts •Assessed inter-coder reliability | <ul style="list-style-type: none"> •Developed framework's instructions for the identification of user needs within stories •Developed class exercises and assignments for four labs •Facilitated four in-class labs | <ul style="list-style-type: none"> •Developed questionnaire for stakeholder critiques of functionality, usability, and overall appropriateness of design within an ER setting •Assessed content validity of questionnaire items |
| Sample | 29 ER nurses | 9 analysts | 3 analysts | 10 four-person design teams | 3 stakeholder experts |

1.7 Document Overview

This document is comprised of seven chapters. Chapter 2 presents a conceptual model for the role of storytelling in design that was informed by a synthesis of narrative and design research. Chapter 3 presents the Design + Storytelling Framework, which guides designers' use of storytelling as an elicitation and analysis method during user needs analysis. Chapters 4, 5, and 6 present the study's phases (i.e., Elicitation of ER Nurses' Stories, Identification of User Needs, and Framework in Practice) used to develop design guidance for medical device designers in the concept stage of design. Chapter 7 summarizes the contributions, implications, and limitations of this work.

CHAPTER 2. CONCEPTUAL MODEL FOR STORYTELLING IN DESIGN

2.1 Introduction

Opportunities for improvement are abundant within the healthcare domain. The Institute of Industrial Engineers (IIE) Council of Fellows identifies the reengineering of healthcare delivery as a grand challenge facing engineers today (IIE, 2007). Engineers interested in healthcare improvement may refer to the Institute of Medicine (IOM) report *Crossing the Quality Chasm: A New Health System for the 21st Century* for guidance. The report describes six quality dimensions that define and measure healthcare. IOM (2001) defines quality care as safe, effective, patient-centered, timely, efficient, and equitable. While describing the quality dimensions, Dr. Donald Berwick, President of the Institute for Healthcare Improvement (IHI), laments an inefficient healthcare system where “**we lose the ideas of the workforce by not inviting them to join in invention**” (IHI, 2008). Dr. Berwick’s statement reveals an opportunity for medical device designers to improve healthcare quality. Designers should elicit practitioners’ ideas in the earliest stage of design (i.e., the concept stage) to identify opportunities for new devices that can improve healthcare quality for both the practitioner and the patient. ***Inclusion of practitioners’ ideas within the concept stage of design:***

- Prevents an inefficient healthcare system where valuable practitioner ideas are lost
- Provides designers with insights necessary to identify new design opportunities

2.1.1 Design in healthcare

Design may be viewed as a transition between two spaces: the problem space and the solution space (R. Ravichandar, Arthur, Bohner, & Tegarden, 2008). Successful design of a solution requires a comprehensive understanding of practitioners’ needs within the problem space. Practitioners’ views are represented within the problem space. The problem space is defined by practitioners’ characteristics (e.g., needs, tasks, work environment) using practitioners’ own language. For example, an emergency room nurse’s statement “*Patients rarely remember what medications they are taking. I worry that I may unintentionally cause a drug interaction when I administer a medication.*” is a representation of the problem space (Figure 2).

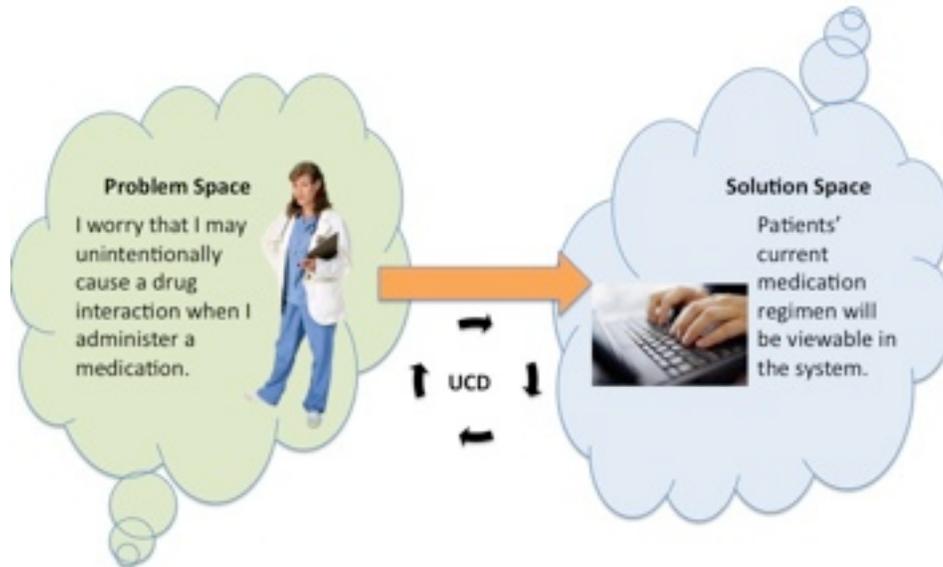


Figure 2. UCD provides a framework for designers to explore the problem space and to identify appropriate design solutions

In contrast, the solution space represents designers' views of the system that addresses the practitioners' needs. Whereas user needs are represented in the problem space, system requirements are represented in the solution space. For example, the electronic health record requirement "*Patients current medication regimen will be viewable in the system*" is a representation of the solution space.

Medical device standards highlight best practices that support designers' transition from the problem space to the solution space. ANSI/AAMI HE: 75 (2009) and IEC 62366 (2007) recommend designers adhere to a user-centered design (UCD) process. UCD is a design framework that encourages comprehensive exploration of the problem space through iterations of user research. Consistent practitioner feedback throughout the UCD process ensures that

- The initial conceptual design is grounded by problem space exploration
- The resulting design is modified and refined based on practitioner evaluations

To minimize risk of designers' misunderstanding the problem space, UCD defines user research as the first phase in process. UCD's emphasis on user research throughout the design process encourages designers to identify user needs prior to the identification of a solution. The UCD framework encourages an iterative exploration of the problem space, which improves designer understanding of user needs. This improved understanding of user needs increases the likelihood that the designed solution will address practitioners' needs. ANSI/AAMI HE: 75 (2009) encourages the use of a UCD process through examples of projects that incorporated revolutionary technology, yet failed in the marketplace as the solution did not address practitioners' needs. For example, the standard notes that although pulse oximetry has been available since the 1970s, the pulse oximeter was not commercially successful until it was designed to meet anesthesiologists' needs for oxygen monitoring during surgery.

Standards also recommend the use of ethnographic methods, such as observations, focus groups, and interviews, during this user research phase. For example, a medical device designer following a UCD process may initially observe ER nurses in an effort to understand nurses' tasks and work environment. After observing practitioners' hectic work schedules and patients' long wait times, the designer may clarify these findings using knowledge elicitation methods. The purpose of knowledge elicitation, such as interviews, is to foster mutual understanding of the problem space so that the resulting conceptual design accurately addresses practitioners' needs.

2.1.2 Domain specific limitations

Unfortunately, domain specific barriers limit the methods that designers may use during problem space exploration within healthcare. For example, designers may need to initially rely on self-report methods during the concept phase of design as institutional review board (IRB) and health insurance portability and accountability act (HIPAA) constraints prevent designers from easily observing practitioners in context (Martin et al., 2006; Martin et al., 2008). In addition, not all knowledge elicitation methods may be appropriate for use within healthcare. For example, designers may have difficulty eliciting information from practitioners using traditional methods, such as Goal-directed Task Analysis, due to a conceptual mismatch between designers and practitioners. Although designers may conceptualize the design problem in terms of goals, practitioners may not view their experiences in this manner (M. Wright, personal communication, February 16, 2010).

2.1.3 Previous work: Initial exploration of storytelling

Considering the barriers to observing practitioners in context, designers require a knowledge elicitation method that elicits this contextual information from practitioners. In previous work we explored the efficacy of storytelling as a knowledge elicitation method during medical device design (Gausepohl, 2008). The impetus for this exploration was Garmer et. al.'s (2002) call for methods that facilitate understanding of the context-of-use in a healthcare environment. We also aimed to address Martin et. al.'s (2008) criticism that human factors methods should be modified to address the unique needs of medical device designers. We chose to investigate storytelling as a self-report method due to the inherent and prolific use of storytelling as a communication technique within the healthcare domain (Borkan, Miller, & Reis, 1992; Calman, 2001; Hunter, 1991), its use by qualitative health researchers in phenomenological studies of healthcare workers' experiences (Wolf & Zuzelo, 2006), its administrative use in training healthcare workers (Mayers, 1995), and its use in healthcare system evaluation (Pottie et al., 2008).

Results of this previous work provide support for the efficacy of storytelling as an elicitation method during device design, yet a comprehensive understanding of storytelling's role during problem space exploration remains elusive. Further investigation is required to gain

understanding of how storytelling may be utilized to meet both designers' and practitioners' needs during contextual analysis.

In this chapter we propose a conceptual model that elucidates storytelling's role during medical device design. In Chapter 4 we present the Design + Storytelling Framework for the use of storytelling during the concept phase of design. First, we present narrative and design research which informed the creation of the conceptual model and resulting Design + Storytelling framework.

2.2 Narrative inquiry as the theoretical foundation for storytelling in design

Designers adapt qualitative research methods for use during design tasks. Qualitative researchers employ ethnographic methods, such as observations and interviews, during phenomenological studies. The purpose of a phenomenological study is to understand the “lived experiences” of a population. Designers' adaptation of qualitative methods is appropriate due to the similarities between designers' and qualitative researchers' goals. For example, designers must also gain an understanding of practitioners' lived experiences to identify user needs during problem space exploration in order to develop an appropriate solution (Figure 3).

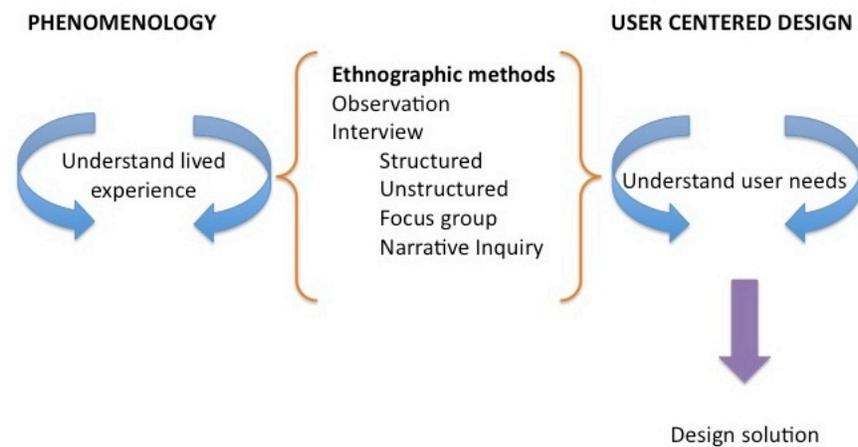


Figure 3. UCD uses ethnographic methods to understand user needs to design an appropriate solution

Current design standards do not mention the potential benefits of narrative inquiry as an ethnographic method during design. This omission is surprising considering the prominence of narrative inquiry within qualitative research (Cortazzi, 1993; Mishler, 1986; Riessman, 1993) and the use of narrative inquiry to understand the experiences of healthcare workers (Chapple,

Ziebland, & McPherson, 2006; Shield, Wetle, Teno, Miller, & Welch, 2005). Considering the lack of appropriate knowledge elicitation methods for use during healthcare systems design, *the use of narrative inquiry methods within medical device design is an opportunity that requires further exploration.*

The following sections provide an overview of narrative and design research that informed the conceptual model developed as a component of this research project. Sections 2.2.1 through 2.2.3 provide an overview of narrative inquiry as an elicitation and analysis method. Section 2.2.4 describes previous work that utilized narrative inquiry to gain insight into experiences and problems unique to the healthcare domain. Section 2.3 provides a review of how storytelling has been used within design projects and Section 2.4 presents the conceptual model.

2.2.1 What is narrative inquiry?

Narrative inquiry is a qualitative research method that involves the elicitation and analysis of personal experiences. In its simplest definition, a narrative is a personal account of experience; however, a universal narrative definition is lacking in the literature (Table 2). For example, narrative can be viewed as a sequential ordering of events with a specific structure (Labov & Waletzky, 1967), as a representation of experience (Riessman, 1993) or as a joint production of storyteller and listener (Mishler, 1986). Narrative may also be viewed as a cognitive schema, as well as the process and product of storytelling (Polkinghorne, 1988). Reading narrative theory is confusing as theorists typically use the terms story and narrative interchangeably. In general, the term story is primarily used to represent the storyteller's perspective of the retold experience, and narrative is mainly used to represent the researcher's interpretation of the experience.

Table 2. Narrative theorists' definitions for story and narrative

| Theorist | Narrative (i.e., story) |
|-------------------------|---|
| Labov & Waletzky (1967) | Structured “oral versions of personal experience” following a temporal sequence |
| Mishler (1986) | Joint production that results from discourse |
| Polkinghorne (1988) | Process and product of storytelling Cognitive schema |
| Riessman (1993) | Representation of experience |

Based on a review of the narrative theory literature, we operationally defined narrative as “a representation of personal experience (i.e., a story) formed by content and structure”. Our definition is influenced by Riessman’s and Labov & Waletzky’s definitions. We view the themes embedded within the story as representations of the narrative’s content. The way in which the storyteller organizes the story is a representation of the narrative’s structure. We provide a detailed overview of the content and structure of narrative in Section 2.2.3.

2.2.2 Elicitation of narratives

Narratives are elicited using a modified interview protocol. Unlike standard interviews, which promote a question-and-answer discourse, narrative interviews encourage participants to tell stories (Riessman, 1993). The narrative interview protocol differs from a standard interview protocol in several ways. First, narrative interview questions are phrased in a manner to encourage participants to retell experiences. For example, a narrative interview will contain open-ended questions, such as “Please tell me your story about [x] in as much detail as possible” (Chapple et al., 2006). This question phrasing shifts the control of the elicitation session from the researcher back to the participant. For example, the open-ended nature of the questions allows participants to discuss aspects of the experience that the participant deems important. A criticism of traditional interviews is that interviewer-created questions impose the interviewer’s framework on the participant (Maiden & Rugg, 1996), which results in a session that elicits information that is important to the interviewer, but not necessarily important to the respondent.

Although it is possible to elicit stories during standard interviews, it requires an adept interviewer who asks the “right” questions and provides freedom of response through the use of long pauses (Riessman, 1993).

Second, narrative interviews are semi-structured to allow for probing questions. Following Mishler’s (1986) contention that narratives are co-constructed by storyteller and listener, the listener may use probing questions to influence the story told. Probing questions are used to influence the story’s direction and level of detail. For example, in response to the probing question, “How did your working relationship with the attending doctor change after the medication error?” a nurse may re-focus her story to highlight the social structure within the hospital, which provides valuable contextual information. However, the listener must also be aware that non-verbal cues may impact the storyteller’s version of the story. For example, if the listener’s eyes widen during a nurse’s description of an error, the nurse may not reveal the full severity of the error. The nurse may decide to tell a story with a reduced level of detail due to the fear of being judged by the listener.

2.2.3 *Analysis of narratives*

In addition to the elicitation of stories, narrative inquiry also involves the analysis of stories in terms of content and structure. Section 2.2.3.1 describes how narrative inquiry methods (e.g., thematic analysis) facilitate understanding of the content embedded within stories. Section 2.2.3.2 describes how structural analysis is used to organize free-form stories into concise and consistent narratives.

2.2.3.1 Content

In narrative inquiry, audio-recordings of elicitation sessions are transcribed to facilitate analysis of the narrative’s content and structure. Researchers use thematic analysis to analyze transcribed narratives for content. If the researcher has approached the research problem from a grounded theory perspective, he or she identifies emerging themes through repeated readings and constant comparisons of the content (Charmaz, 1999). Alternatively, the researcher may use a “block and file” approach to identify themes of interest within the narrative (Grbich, 2007). The difference in the two approaches is due to the focus of research question. If the overall research

question is broad and the purpose of the research is to develop theory, the researcher's goal is to identify emerging themes to develop theory. In contrast, if the purpose of the research is to test a theory, the researcher searches for themes of interest to support a research hypothesis.

2.2.3.2 Structure

In addition to methods for analyzing stories for content, narrative inquiry also provides guidance for the analysis of stories in terms of structure. A review of narrative analysis literature reveals several methods to analyze narratives for structure, such as Riessman's (1993) use of stanzas. The most prevalent method is Labov & Waletzky's (1967) method for analyzing narratives based on structural components. These structural components are: complicating action, abstract, orientation, resolution, evaluation, and coda (Table 3). According to Labov & Waletzky, narratives must contain a complicating action (i.e., a temporal sequence of statements that provides the narrative's plot). All remaining structural components are optional. The abstract provides a story summary and the orientation provides contextual information, such as descriptions of the setting and character(s). Statements that describe the result of the complicating action form the resolution. The evaluation component represents the storyteller(s)' reflection on the event. The coda consists of statement(s) that signal the end of the story and returns the speaker to the present day.

This structural approach is a method to organize and reduce practitioner's stories into concise narratives that contain important statements of interest. For example, the structural approach can reduce a practitioner's lengthy story into a succinctly organized narrative that maintains the storyteller's perspective (Table 3).

Table 3. Example narrative statements for Labov & Waletzky's (1967) structural components

| Structural component | Example narrative statement | Required? |
|-----------------------------|---|------------------|
| Abstract | My more successful patient infusion | No |
| Orientation | Trust me, I was really, like, shaking because this is a chemo. | No |
| Complicating action | She was, like, really – I would say crashing. Put her on nitrogen. Five milligrams didn't do good. | Yes |
| Resolution | The patient ended up in the unit because her blood pressure – that's when she started going down too. | No |
| Evaluation | So the infusion pump is kind of – it's one of the tools that we use for patient safety. | No |
| Coda | So that is what happened that day. | No |

2.2.4 Narrative inquiry in healthcare

A review of the literature supports the use of narrative inquiry as a means to understand experiences within a healthcare context. For example, healthcare researchers use narrative inquiry in an effort to understand practitioners' experiences in the workplace. Researchers often collect practitioners' oral narratives during face-to-face interviews. Mcilpatrick, Sullivan & McKenna (2006) elicited experience narratives from ten chemotherapy nurses to compare differences in working within a hospital and inpatient setting. Analysis of narratives for common themes revealed positive and negative aspects of working in both inpatient care and hospital settings. For example, nurses appreciated the opportunity to form a relationship with patients in inpatient care, yet regretted the stressful work environment.

Livesley (2005) collected stories of nurses' experiences working with unaccompanied hospital children. The purpose of the research was to explore how nurses define "unaccompanied children" and to determine nurses' strategies for working with these children. Nurses' day-to-day experiences were elicited using an unstructured interview protocol containing questions, such as "What comes to mind when you think of children alone in the hospital?" Livesley analyzed nurses' stories using a modified version of Labov & Waletzky's (1967) structural components to extract important narrative statements from nurses' accounts of experience. Based on this analysis, Livesley determined that an important strategy for constructing professional boundaries was nurses' ability to acknowledge the difference between caring for and parenting a sick child.

Healthcare researchers also collect patients' stories in an effort to understand patient experiences. Chapple, Ziebland, McPherson (2006) conducted narrative interviews with 41 patients to explore patients' perspectives of the role of the palliative care nurse. The researchers employed a grounded theory approach to thematic analysis in which themes were identified through constant comparison. This thematic analysis revealed opportunities for scheduling improvement, as some patients were confused by the involvement of a palliative care nurse in early stages of disease.

The above review of narrative research literature reveals several opportunities for designer use of these methods within UCD. We suspect that narrative inquiry elicitation and analysis methods when applied to the design domain will provide designers with the ability to:

- Manage and analyze user research data
- Understand healthcare experiences, which is necessary during problem space exploration
- Consider the experiences of different stakeholders

Although the above review of narrative inquiry research provided the theoretical foundation for the conceptual model presented in Section 2.4, a review of designers' utilization of storytelling was necessary to ensure that the model adequately addressed practical needs during design tasks. Section 2.3 provides a review of storytelling's uses in design.

2.3 Storytelling in design

A review of design research literature reveals an increased interest in stories as a means to alleviate communication problems between designers and stakeholders. Successful communication between designers and stakeholders is necessary for the design of systems and products that address users' needs. Communication problems are often cited as a contributing factor towards ultimate design failure (Standish Group, 1994). Inadequate communication prevents designer understanding of the problem space, which is required to identify an appropriate design strategy for the solution space (Figure 2). User needs analysis and subsequent requirements elicitation requires "intensely interactive and demanding communication" (Alvarez & Urla, 2002). Communication is complicated by conflicting stakeholder viewpoints (Kim, Lund, & Dombrowski, 2010), lack of user engagement during design meetings (Wagner & Piccoli, 2007), and difficulty eliciting contextual information during interviews (Mishler, 1986).

Alvarez & Urla (2002) encourage designers to rethink communication strategies with the suggestion that "*perhaps it's not requirements that we should ask for, but rather a good story.*" Although interest in stories has increased since this suggestion, further review of the literature reveals discrepancies in design researchers' definitions for story and narrative (Table 4), similar to previous discrepancies in definitions within narrative inquiry research (Table 3). It is

interesting to note that narrative theorists tend to use the term “narrative” by default, while design researchers primarily use the term “story”.

Alvarez & Urla (2002) define story as a process that results in narratives. During requirements engineering for an enterprise resource planning (ERP) system, elicited narratives became rich and organized representations of workers’ practices and perspectives. Storytelling provided designers the ability to gather contextual information embedded within the narratives.

Table 4. Story and narrative definitions in design literature

| Design Researcher(s) | Story | Narrative |
|------------------------------|--|--|
| Alvarez & Urla (2002) | “an embedded and fragmented process in which gaps are filled in by the teller and audience”, p.40. | “Representational forms that provide valuable data about work practices and individual worker perspectives, as well as the larger organizational political and cultural contexts....”, p.40. |
| Denning (2004) | Tool leaders use to get a desired response | Used interchangeably with story |
| Wagner & Piccoli (2007) | Workers’ identification of challenging and successful work practices | Used interchangeably with story |
| Kim, Lund, Dombrowski (2010) | “have an arc that reveal change”, p.25. “define where technology and users mismatch, p.26. | Used interchangeably with story |
| Madsen & Nielsen (2010) | Series of sequential events | Narratives create a world that undergoes change and “allow the reconstruction of an interpretive network of goals, plans, causal relations, and psychological motivations around the narrated events”, p.60. |

Wagner & Piccoli (2007) apply Cacioppo & Petty's (1984) elaboration likelihood model to explain communication problems within UCD. Elaboration likelihood is a model of human persuasion that identifies motivation and information processing as two components necessary for attitude change. Application of the elaboration likelihood model to design is appropriate considering the importance of persuasion during design meetings. For example, users must convince designers that user needs are important. Users must also encourage designers to create a solution that addresses these needs. For user acceptance of the completed design, designers also need to persuade users that the solution matches the previously identified needs.

Wagner & Piccoli argue that communication is affected by how users are included in the design process. Designers must include users at appropriate points and to facilitate user focus on the design problem. The researchers suggest the elicitation of user stories will alleviate these timing and focus issues. For example, allowing users to tell their own stories fosters user engagement in the design process. Storytelling focuses designer and user attention on the design problem at the initial stages of design. Wagner & Piccoli use the term story and narrative interchangeably to refer to “descriptions of successful and challenging ways of working.” Although these stories provide insight into user needs, Wagner & Piccoli lament that designers lack training in narrative interpretation. According to Wagner & Piccoli, *the ability to elicit and analyze user stories is a skill that is “increasingly recognized as crucial” in design.*

Denning (2004) also values the persuasive power of stories. Denning views stories / narratives as tools that business leaders use to garner a desired response. For example, Denning used “sparkling action” stories to encourage the World Bank's design of a knowledge management system. Project success was compromised by initial limited stakeholder interest; however, Denning's stories persuaded stakeholders of the project's importance.

Leaders with identified objectives may use Denning's storytelling catalog (e.g., sharing knowledge, communicating who you are) to inspire desired stakeholder responses. For example, a sharing knowledge story communicates the impact of unresolved problems, which causes the listener to acknowledge potential negative implications of ignoring the problem. In this respect, a sharing knowledge story is a means to facilitate focus on the design problem. Sharing knowledge stories also facilitate project buy-in from stakeholders. Although Denning's focus is the project leader telling stories to stakeholders, there is an opportunity for project leaders to elicit stories from stakeholders in an effort to understand the design problem. For example, a

designer who wants to encourage user engagement in the design process may purposefully elicit a “sparkling action” story from a stakeholder. In this respect, *Denning’s storytelling catalog is not simply a list of potential stories for project leaders to tell, rather a listing of stories to elicit from stakeholders.*

Storytelling’s ability to focus stakeholder attention on the design problem has also been recognized by Kim, Lund, & Dombrowski (2010). The researchers view storytelling as a tool for innovation as stories align stakeholder interests and spark design ideas. The terms story and narrative are used interchangeably to refer to an event that reveals a change. Stories are valuable to designers because they “define where technology and users mismatch.” In this respect, *stories are instantiations of design opportunities.*

Similar to the Kim et. al. definition, Madsen & Nielsen (2010) view narratives as representations of a world that undergoes change. However, the influence of narrative theory is evident in the researchers’ separate definitions for story and narrative. A story is viewed simply as a series of sequential events, which adheres to Labov & Waletzky’s (1967) focus on sequence. The influence of Mishler’s (1986) contention that knowledge is co-constructed during storytelling is evident in the narrative definition that describes its role fostering “reconstruction”.

Similar to Denning, Madsen & Nielsen view storytelling as the creation of stories and not the elicitation of stories. The researchers provide a procedure for design teams to create persona-scenarios, which describe a problem from the user’s viewpoint. Although user representatives are included in the persona-scenario creation process, the procedure limits direct user input. The procedure encourages the creation of *hypothetical* stories about a *hypothetical* user based on a *hypothetical* “start situation” (e.g., “Karina has a digital signature and would like to report wage statistics...”). The researchers miss an opportunity to elicit narratives directly from users and convert them to persona-scenarios that represent a *realistic* story about a *realistic* user. Another limitation of this work is although the researchers mention that requirements can be elicited from persona-scenarios, designers are not provided with a procedure for extracting this information. Although the researchers’ use of narrative research as the foundation for persona-scenarios represents a step in the right direction, *we believe further opportunities exist for the application of narrative theory procedures and methods within the design domain.*

2.4 The conceptual model

The conceptual model created during the course of this research presents storytelling as a design method that consists of two separate processes: (1) the storytelling activity and (2) the storytelling analysis. When employed during the concept phase of UCD the storytelling method facilitates designers' ability to identify a design opportunity informed by user needs and an understanding of the context-of-use gleaned from stakeholders' stories (Figure 4).

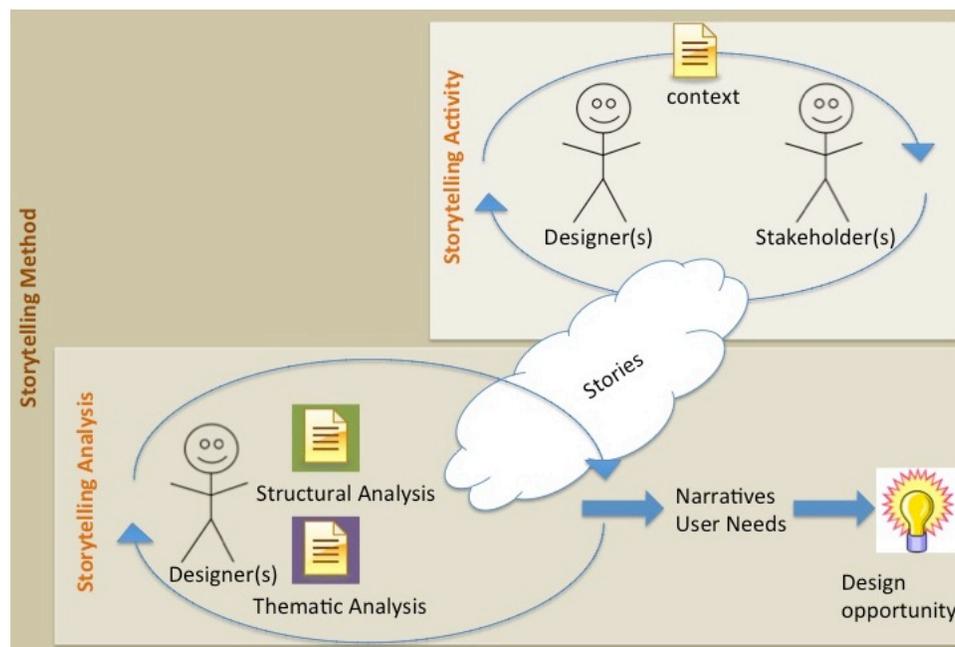


Figure 4. Conceptual model for the role of storytelling in design

In the storytelling activity, designers elicit stakeholders' stories relevant to the current design problem. Designers alter the storytelling context in an effort to encourage stakeholders to share desired information. The conceptual model considers the interview protocol and setting as aspects of the context. For example, designers may alter the questions within the protocol since interview prompts influence the types of stories practitioners tell, as well as the detail in which the stories are told. Since stories are co-constructed (Mishler, 1986), the stories told within an individual interview will vary from those told within a group setting. Alterations of the setting may be necessary to elicit desired information. For example, designers interested in the collection of stories related to controversial topics, such as medical error, may choose to conduct

individual one-on-one sessions to reduce nurses' hesitation to share medical error stories due to fear of negative professional consequences.

Stakeholders' stories, which are the output of the storytelling activity, serve as the input to storytelling analyses. Designers employ methods used within narrative inquiry, such as structural and thematic analysis, to analyze stakeholder stories for information relevant to design. Structural analysis is used to organize free-form stories into concise and consistent narratives, which become design artifacts used throughout the design process. Designers use thematic analysis to identify functional and usability needs within the narratives. According to the conceptual model, the information gleaned from the narratives, which includes an understanding of the context-of-use, supports designers' identification of a design opportunity within the explored problem space.

Similar to Polkinghorne (1988) the conceptual model presents a process and product approach to storytelling. The storytelling activity (i.e., a process) results in the collection of stakeholder stories (i.e., a product), which are explored by designers during storytelling analysis (i.e., a process) to identify a design opportunity informed by user needs (i.e., a product). Sections 2.4.1 and 2.4.2 present the theoretical and practical foundations for the activity and analysis processes within the storytelling method described in the conceptual model.

2.4.1 The storytelling activity

Similar to Wagner & Piccoli (2007), we view the storytelling activity as a process that supports designer and stakeholder engagement through elaboration likelihood (Figure 5). Increased engagement is desired as design literature identified communication problems as a root cause of design failures (Standish Group, 1994).

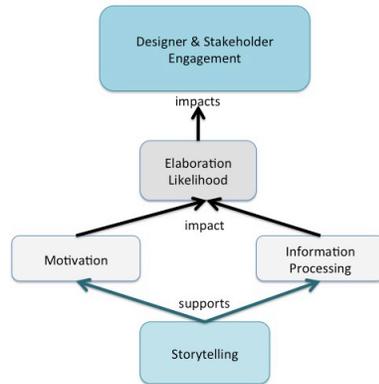


Figure 5. Storytelling facilitates designer and practitioner engagement

The storytelling activity supports motivation and information processing ability, which in turn increases elaboration likelihood. This increase in elaboration likelihood results in increased designer and practitioner communication and engagement during the design process. Section 2.4.1.1 provides an overview how the storytelling activity supports motivation. Section 2.4.1.2 describes how the storytelling activity supports information processing.

2.4.1.1 The storytelling activity supports motivation

From the designer’s perspective, requirements elicitation is a work task with an immediate goal of increased understanding of the problem space. The designer’s long-term goal is to create an appropriate solution based on the needs identified during requirements elicitation. Application of Locke’s (1968) goal-setting theory reveals how the storytelling activity enhances the designer’s motivation towards these goals. According to goal-setting theory, designer motivation is greater for specific goals than vague ill-defined goals. Stakeholders’ stories, which are the product of the storytelling activity, provide designers with detail-rich information. The quality of information elicited from the storytelling activity supports designers’ transition from ill-defined user needs to specific user needs.

Locke & Latham (2006) identify goal commitment as a moderator for worker motivation. In goal-setting theory motivation increases as goal commitment increases. Business leaders have identified the sharing of stories as a means to foster worker motivation. For example, Dennig (2005) and Heath (2007) suggest leaders tell “springboard” stories, which focus on future possibilities, to motivate workers towards long-term goals.

In addition, a cognitive advantage of the storytelling activity is that stories influence the attitude and behavior of the listener (Swap, Leonard, Shields, & Abrams, 2001). For example, a designer may be motivated to create an improved infusion pump tubing system after listening to a practitioner's story that highlights the frustration experienced through use of the current system. In this respect, the practitioner's story has sparked designer commitment to the goal of an improved tubing system.

2.4.1.2 The storytelling activity supports information processing

In general, the purpose of an elicitation session is to transfer knowledge in the effort to create mutual understanding between two parties. During a design task the purpose of the elicitation session is to foster a comprehensive understanding of the problem space so that an appropriate solution can be created. Although the storytelling activity supports engagement between stakeholders and designers (See Section 2.4.1.1), designers must consider the cognitive advantages and disadvantages imposed by the storytelling activity on the storyteller and listener.

Storytelling provides cues, which provide a cognitive advantage to the storyteller. For example, requests for stories, such as "Please tell me about a story about a time you felt your use of an infusion pump was inefficient", provide recall cues for storytellers. These cues assist the storyteller's recall since episodic memory is cue dependent (Gronlund, Carlson, & Tower, 2007). Also, the open-ended nature of storytelling allows the storyteller to convey the requested information according to his or her existing schema. A criticism of traditional interviews is that interviewer-created questions impose the interviewer's framework on the participant (Maiden & Rugg, 1996), which results in a session that elicits information that is important to the interviewer, but not necessarily important to the respondent. In contrast, storytelling requires less storyteller cognitive processing since the storyteller does not have to process information to fit into the interviewer's framework during information reporting. Storytelling is also beneficial to the storyteller because the mere act of storytelling assists the respondent in making sense of his or her experiences (Bleakley, 2005; Greenhalgh & Wengraf, 2008). For example, Olson (2008) believes that storytelling is beneficial to the storyteller because it provides an opportunity to learn through reflection. The storyteller's expertise can also provide a cognitive advantage since recall is enhanced when the story is meaningful to the storyteller (Tulving & Markowitsch, 1998). For example, the request for a nurse's story relating to patient safety will provide a

cognitive advantage since the topic of patient safety is meaningful to a nurse working in an environment where patient safety is paramount.

One disadvantage of storytelling is that personal troubling stories may cause storyteller discomfort or stress, which may impede the collection of these stories. Although emotional experiences are more likely to be encoded into episodic memory (Tulving & Markowitsch, 1998), emotionally pleasant memories are more likely to be voluntarily retrieved and rehearsed. Following Ebbinghaus's decay theory (1913), this implies that the preference to retrieve and rehearse positive experiences delays retrieval decay, while the ability to retrieve negative stories decays over time due to a lack of rehearsal.

Storytelling provides the listener with cognitive advantages and disadvantages as well. Since stories express information in a memorable form, the story is more likely to influence the attitude and behavior of the listener (Swap et al., 2001). This is a desired result of a requirements gathering elicitation session, since one of the purposes of the session is to provide the designer with an understanding of the user's needs from the user's perspective. In this respect, one of storytelling's advantages is that it provides an opportunity for the requirements engineer to empathize with the user, which may foster a user-centric design approach over a system-centric design approach.

Another cognitive advantage for the listener is that the story provides a summary of the temporal order of events, which helps the listener discern potential cause and effect relationships. For example, when a nurse tells a story of a sentinel event, the temporal order of the story will help the listener discern potential causes of the event.

A listener disadvantage is that although the storyteller uses his or her framework to tell the story, the listener will apply existing schemas during story interpretation (Bartlett, 1932). The use of different schemas during storytelling and story interpretation introduces the possibility for misunderstandings between the storyteller and listener.

2.4.2 *Storytelling analysis*

The conceptual model leverages existing analysis methods (i.e., structural analysis, thematic analysis) used within narrative inquiry for use during design tasks. Designers utilize Labov & Waletzky's (1967) structural analysis approach to organize stakeholders' stories into narratives created by a precise ordering of structural components (i.e., abstract, orientation,

complicating action, resolution, and evaluation). Since coda statements (i.e., responses that signify the end of the story) are not relevant to design, the conceptual model purposefully excludes these statements from analyses.

Designers also employ thematic analysis to identify functional and usability needs within stakeholders' narratives. In contrast to qualitative inquiry's use of thematic analysis to identify themes relating to a research question, designers use thematic analysis to identify information relevant to a design problem. Designers benefit from the use of thematic analysis as it provides a structured process for the identification of user needs. Section 2.4.2.1 summarizes additional benefits of the analysis process within the storytelling method presented in the conceptual model.

2.4.2.1 Storytelling analysis supports design

According to the conceptual model, designers first use structural analysis as a tool to manage and organize practitioners' stories into a concise narrative. ***These concise narratives provide several benefits during design:***

- The narratives act as artifacts of user research that maintain the practitioners' voice and perspective.
- These artifacts can be shared between design team members to facilitate communication and focus on the design problem.
- The narratives can also be shared with other stakeholders to encourage further discussion.

The concise narratives also provide a reduced data set for further content analysis. In our model, designers use thematic analysis to identify user needs and contextual information embedded within the narratives. ***This thematic analysis provides several benefits during design:***

- The designers' ability to acquire this information facilitates designers' exploration of the problem space.
- This exploration supports the ultimate designer goal of identifying a design opportunity within the solution space.

2.4.3 Implications of the conceptual model

According to the conceptual model, designers may alter the storytelling activity to influence the information elicited from stakeholders. Since the quality of information elicited directly impacts designers' ability to identify a relevant design opportunity, guidance in how to alter the context is needed to maximize information quality. However, design literature lacks empirical findings that investigate the quality of information obtained under varying contexts.

One goal of this research project is to explore the impact of the storytelling context on the information elicited during the storytelling activity in an effort to provide designer guidance.

Towards this goal, we created the Design + Storytelling Framework, which is based on the conceptual model for the role of storytelling in design described within this chapter. Chapter 3 presents the Design + Storytelling framework and the four alterations to the storytelling context explored during this work (i.e., Methods IHH, GHH, IH, GH). In Chapter 4 through Chapter 6 we present research findings of our theoretical and practical exploration of the Design + Storytelling framework.

CHAPTER 3. THE DESIGN + STORYTELLING FRAMEWORK

The Design + Storytelling framework guides designers in the use of storytelling as a knowledge elicitation method during the concept phase of design (Figure 6). The framework is based on the conceptual model (Figure 4) described in Section 2.4. The impetus for this work was the potential for the Design + Storytelling framework to contribute to the Prevention through Design (PtD) initiative in healthcare.

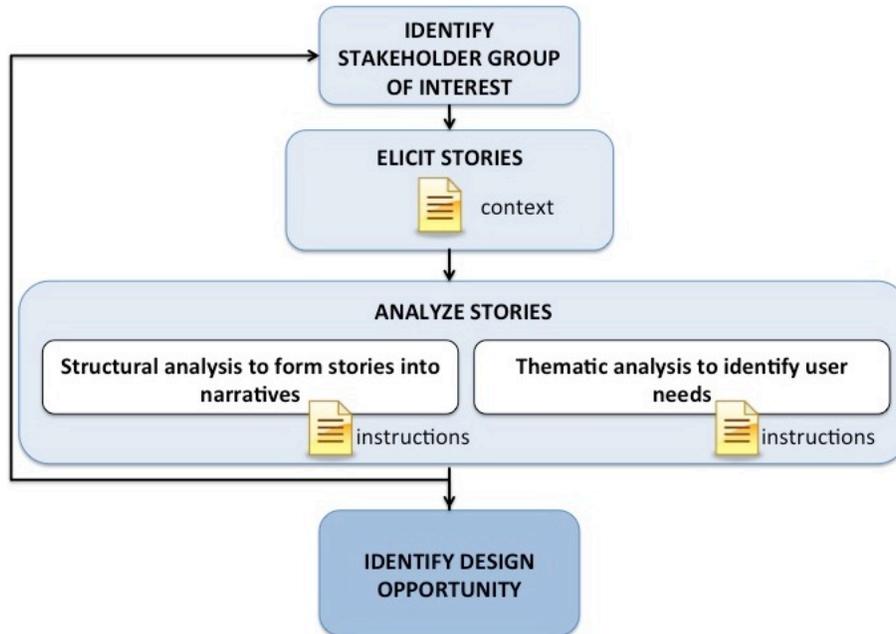


Figure 6. The Design + Storytelling framework

The framework represents an iterative approach to requirements gathering. Within each iteration designers: (1) identify stakeholders, (2) elicit stakeholders' stories and (3) analyze stories to identify user needs relevant to design. The purpose of the framework is to assist designers in the elicitation and analysis of stakeholders' stories during user needs analysis. In this respect, the framework supports the identification of a design opportunity that is based on the discovered user needs.

Section 3.1 identifies the connections between the conceptual model (See Section 2.4) and the stages within the Design + Storytelling framework that guide designers through problem exploration. Section 3.2 presents the instantiation of the framework that was explored during this research project. Since frameworks are descriptive and not prescriptive in nature, the Design + Storytelling framework represents an overall approach for the use of storytelling in design.

The framework described in Section 3.2 represents the application of the framework in support of the identification of a design opportunity within an emergency room (ER), which was the chosen domain for this work. Section 3.3 describes the research questions explored during this research as part of a theoretical and practical exploration of the Design + Storytelling framework.

3.1 Connections between the framework and the conceptual model

The four stages within the Design + Storytelling framework reflect components within the conceptual model (Figure 7). For example, the representation of the storytelling method as two separate processes (i.e., storytelling activity, storytelling analysis) within the conceptual model informed the creation of distinct stages (i.e., *Elicit Stories*, *Analyze Stories*) within the framework. In the framework's first stage designers identify stakeholders of interest to engage in the storytelling activity. Once stakeholders have been identified and recruited for knowledge elicitation sessions, designers elicit stories relevant to design in the *Elicit Stories* stage. This second stage of the framework represents the storytelling activity in the conceptual model. Since the conceptual model identified the context of the storytelling activity as an important factor relating to the quality of information elicited, the framework also highlights its importance. Designers then analyze the collected stories in the third stage of the framework, which represents the storytelling analysis process in the conceptual model. The framework leverages the use of structural and thematic analyses as narrative analysis methods in the instructions provided to designers. The outputs of the third stage (i.e., narratives, user needs, understanding of the context-of-use) encourage the identification of a design opportunity within the final fourth stage. Depending on the complexity of the design problem, designers may choose to iterate through the initial three stages several times prior to finalizing the identification of the design opportunity.

A detailed overview of the stages within the framework is provided in Sections 3.2.1 through 3.2.4. The stages are described in the context of a medical device design problem to elucidate how the general framework may be adapted to suit a design problem within a specific domain, such as healthcare.

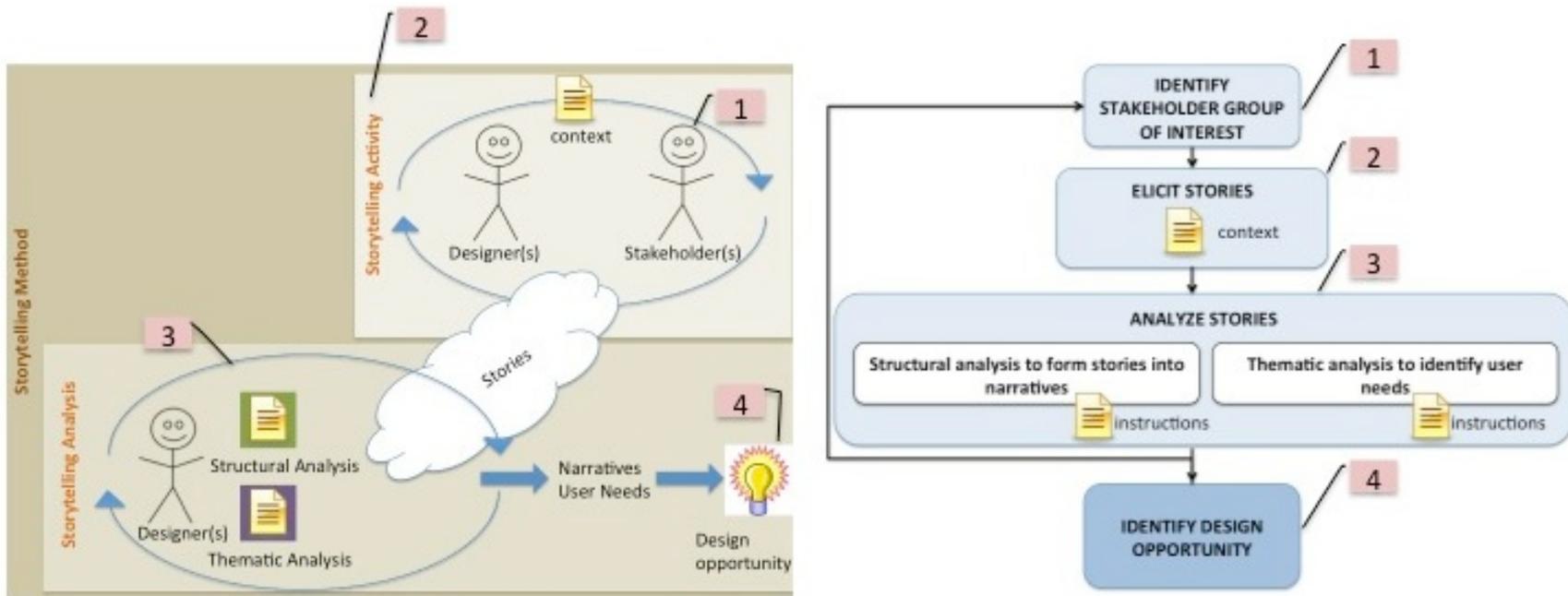


Figure 7. Stages within the Design + Storytelling framework are based on aspects of the conceptual model

3.2 Instantiation of the Design + Storytelling framework explored in this work

As an overall goal of this research is to close the identified Prevention through Design (PtD) gap in medical device usability, an instantiation of the Design + Storytelling Framework was created to represent its use within healthcare. Specifically, this framework guides designers through problem exploration within an emergency room environment (Figure 8). In contrast to the general framework (Figure 6), this instantiation does not include multiple iterations of the first three stages. Although other stakeholders, such as patients, should be included during problem exploration within healthcare, a reduction in scope was appropriate given the exploratory nature of this work. This framework provided direction for the exploration of the impact of the framework on design, which is presented in Chapter 4 through Chapter 6.

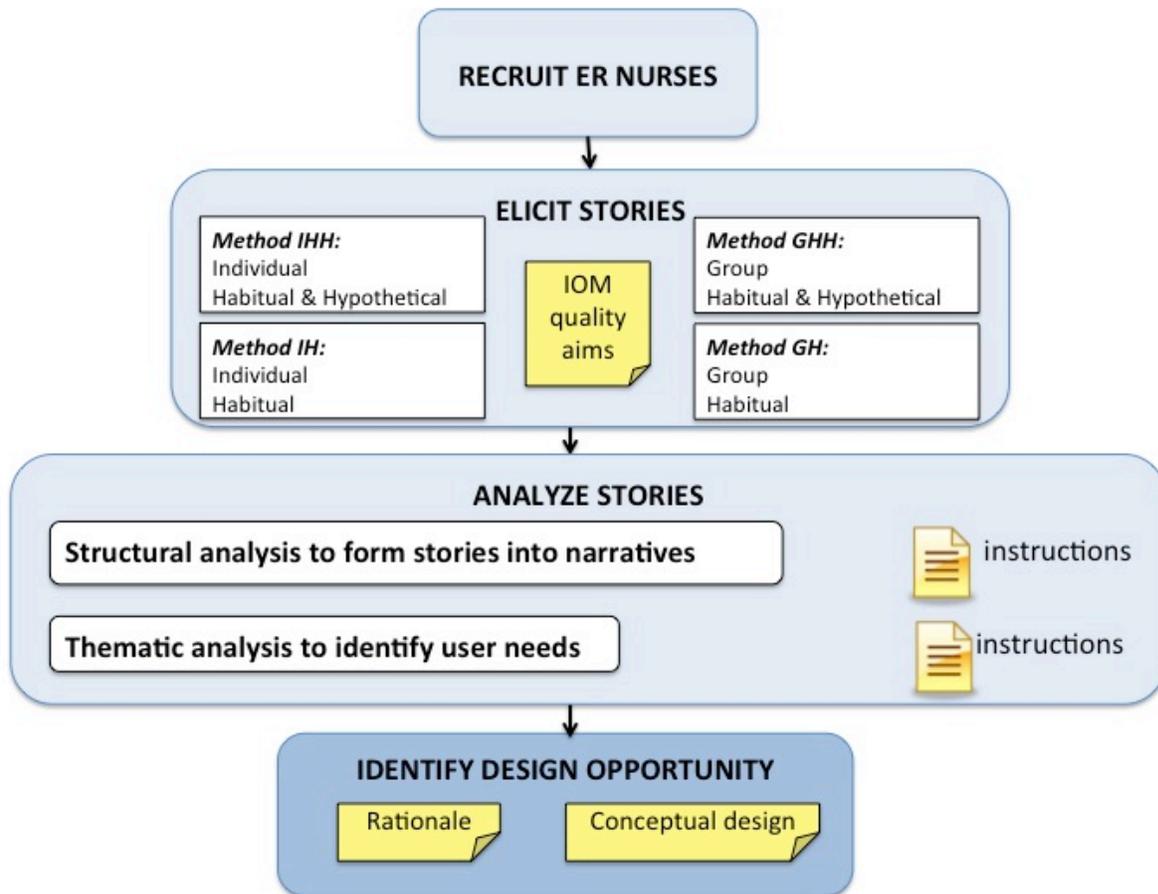


Figure 8. Instantiation of the Design + Storytelling framework explored during this work

This instantiation of the Design + Storytelling framework guides designers' use of storytelling as a knowledge elicitation method during problem exploration within an emergency room. The framework guides designers towards the recruitment of ER nurses as relevant

stakeholders of interest. The framework offers the use of four distinct elicitation methods, which represent variations of the storytelling context in terms of question prompts (i.e., habitual, habitual and hypothetical) and setting (i.e., group, individual). As in the general Design + Storytelling framework, this instantiation provides guidance for the analysis of nurses' stories; however, this framework provides additional guidance towards the identification of information relevant to healthcare design. The framework guides designers' formation of nurses' responses into concise and consistent narratives through the provided structural analysis instructions (See Appendix C). Designers' identification of user needs from nurses' narratives is also supported by the framework's thematic analysis instructions. These instructions incorporate a requirements ontology specific to healthcare design with an iterative process of user need specification guided by grammar rules (See Appendix C). The framework also supports the documentation of identified design opportunities through templates for the specification of design rationales and conceptual designs (See Appendix C). The design rationale template encourages designers to provide substantiation of the design opportunity through references to user needs identified within narratives, which supports traceability between the proposed solution and the identified problem. The conceptual design template included within the framework encourages designers to document storyboards, scenarios, and sketches that describe the functionality and usability of the proposed solution.

Sections 3.2.1 through 3.2.4 describe the four stages within the framework and highlight design guidance specific to healthcare.

3.2.1 Stage 1: Identify stakeholder group of interest

The Design + Storytelling framework requires designers to identify a general problem area of focus prior to use of the framework. For example, a medical device company may select medication delivery as a problem area of focus. In the first stage of the framework, designers identify stakeholders within the problem area to engage in the storytelling activity. In general, project stakeholders are individuals who are impacted by project success or failure, such as managers, employees, and designers (Vink, Imada, & Zink, 2008). In the realm of medical device design, project stakeholders may include hospital administrators, physicians, nurses, anesthesiologists, pharmacists, home health care aids, patients, and designers. Stakeholder identification is important because practitioners' stories are the source for user needs (Figure 7).

The framework's iterative nature encourages the inclusion of all stakeholders, following Martin et. al's (Martin et al., 2006) warning that medical device users are a "heterogeneous group".

3.2.2 *Stage 2: Elicit stories*

In the second stage, designers elicit stories from identified stakeholders (e.g., nurses, pharmacists, physicians, surgeons). The framework contains example protocols that guide designers during the elicitation sessions. These protocols are based on interview guides obtained from qualitative health researchers to ensure that the framework's protocols represent best practices from narrative inquiry.

The emphasis on best practices is important considering the impact of session context on practitioners' storytelling activity (Figure 7). Exploration of the four methods within the *Elicit Stories* stage supports design guidance for method selection. The protocol questions have also been created to encourage practitioners' storytelling. In previous work (Gausepohl et al., 2011), we prompted practitioners to share stories relating to components of medical device usability (e.g., efficiency, inefficiency, effectiveness, error, satisfaction, & stress). However, in retrospect these questions have a designer-centric view of the problem space. In an effort to guide stories that represent practitioners' view of the problem space, the protocol questions address the Institute of Medicine's (IOM) healthcare quality aims (e.g., effective, efficient, timely, patient-centered, safe, equitable). This shift from designer to practitioner views of quality follows Polkinghorne's (1988) notion that one of narrative inquiry's benefits is the storyteller's affordance to discuss topics important to the storyteller.

The elicitation protocol contains two types of prompts for each IOM quality aim: habitual prompts and hypothetical prompts (Figure 9). Habitual prompts elicit habitual narratives, which represent practitioners' telling of personal work experiences (Riessman, 1993). For example, the habitual prompt, "Is there a particular instance where your own safety was an issue that stands out?" encourages practitioners to reveal personal experiences where safety was an issue. In contrast, hypothetical prompts elicit hypothetical narratives, which are stories of events that have not happened (Riessman, 1993). For example, the hypothetical prompt "Walk me through how this experience should have been ideally" encourages practitioners to re-frame the story so that the safety issue was addressed or mitigated. In this respect, the hypothetical narrative allows the

practitioner to “re-design” his or her experiences towards the ideal experience. The storytelling activity protocol includes prompts for habitual and hypothetical narratives in an attempt to reveal the discrepancy between practitioners’ actual and ideal work experiences. The gaps between habitual and hypothetical narratives represent design opportunities for designers (Figure 9).

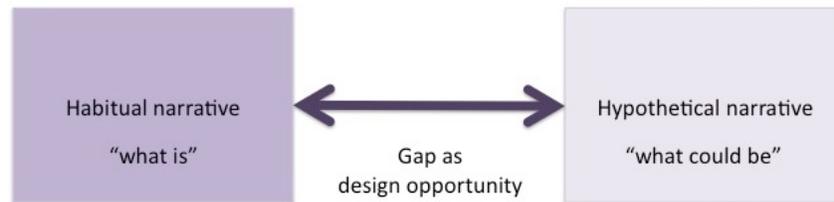


Figure 9. Gap between habitual and hypothetical narrative represents a design opportunity

The setting of the storytelling session is another aspect of the session context that influences practitioners’ storytelling. In previous work, we conducted individual face-to-face storytelling sessions with practitioners. In this work, Methods IHH and IH guide designers through individual face-to-face storytelling sessions with practitioners. In contrast, Methods GHH and GH guide designers during storytelling sessions with groups of practitioners. Interest in the impact of group sessions on the storytelling activity is based on our anecdotal observations of practitioner engagement during focus groups in previous work and Mishler’s (1986) contention that stories are co-constructed.

3.2.3 Stage 3: Analyze stories

In the third stage of the framework, designers analyze transcripts of stories collected during the storytelling activity (i.e., *Elicit Stories*). The purpose of the analyses is to identify user needs and to gain an understanding of the context-of-use. Since practitioners’ stories are formed by structure and content, the framework guides designers in structural and content analyses. An overview of the two analysis steps that guide designers towards the identification of user needs is provided in Sections 3.2.3.1 and 3.2.3.2.

3.2.3.1 Structural analysis to form stories into narratives

Since free-form stories may be unwieldy, the framework provides guidance for the application of structure to nurses' responses. The overall goal is to provide designers with a form of the elicited information that facilitates later identification of user needs. Towards this goal, the first analysis step is to form transcribed stories into concise narratives following Labov & Waletzky's (1967) procedure for structural analysis. The storytelling framework incorporates Labov & Waletzky's approach because this approach is cited in narrative inquiry literature as the most commonly used structural analysis approach.

Structural analysis is the first part of data synthesis. In the Labov & Waletzky technique, the researcher segments the story into sections to assist in interpretation. These sections correspond to the narrative's abstract (i.e., summary), orientation, (i.e., context) complicating action (i.e., plot), resolution (i.e., result), and evaluation (i.e., importance). The framework includes detailed instructions for structural analysis (See Appendix C), which allows designers to incorporate narrative inquiry analysis techniques during design without an extensive background in narrative inquiry or qualitative research.

3.2.3.2 Thematic analysis to identify user needs

The second step within the *Analyze Stories* stage is the use of thematic analysis to identify user needs within the concise narratives created during structural analysis. Thematic analysis is a qualitative research method used to analyze text for content (Creswell, 2007). The storytelling framework provides detailed instructions for conducting thematic analysis using the requirements ontology created in previous work (Gausepohl, 2008) and an iterative process of user need specification guided by grammar rules (See Appendix C). Similar to the structural analysis instructions, the thematic analysis instructions assume no previous experience in narrative inquiry or qualitative methods. The thematic analysis instructions within the framework guide designers through the identification and specification of user needs relative to healthcare design. For example, the instructions guide the designers towards the identification of user needs related to "hygienic context" as proposed solutions must conform to the sterile conditions and requirements of a hospital environment.

3.2.4 Stage 4: Identify design opportunity

The final stage of the storytelling framework is the identification of a design opportunity. Designers identify design opportunities based on the user needs and contextual information embedded within practitioners' stories (Figure 7). We anticipate that the storytelling framework will assist designers in: (1) the elicitation of desired information relevant to design and (2) the analysis of stories to identify information relevant to design. We suspect that the framework's systematic analysis methods in support of problem space exploration will foster designers' ability to identify user needs and contextual information relevant to design. We anticipate that this improved understanding of the problem space will aid designers' selection of a design opportunity documented within a design rationale and conceptual design. Section 3.5 presents the research questions addressed in this study's investigation of the Design + Storytelling framework. As the overall purpose of the framework is to facilitate designers' transition between the design problem space (i.e., user needs analysis) and solution space (i.e., conceptual design), the research questions explore the framework's impact on design in terms of the quality of information elicited in the storytelling activity and the quality of design artifacts (e.g., set of user needs, conceptual design documenting identified design opportunity) created as a result of storytelling analysis.

3.3 Research questions addressed in the investigation of the Design + Storytelling framework

The primary goal of this work was to present storytelling as a knowledge elicitation method that addressed the PtD call for methods that improve usability within healthcare. The creation of the Design + Storytelling framework supports this goal as it guides designers' use of storytelling during the conceptual design phase of a project. The overall research question for this study explored the efficacy of the framework as a support tool that positively impacts design. Additional research questions explored the impact of the framework's two primary stages on design. RQ1 explores the differences between framework's four methods (i.e., IHH, IH, GHH, GH) in the *Elicit Stories* stage on the resulting user needs elicited. RQ2 explores the impact of the instructions included within the *Analyze Stories* stage on design. Section 3.3.1 highlights connections between the study's research questions and framework components.

3.3.1 RQ: How does the Design + Storytelling framework impact design?

Two research questions supported the exploration of the framework’s overall impact on design (Figure 10). In an effort to provide designers with guidance for the selection of an appropriate elicitation method, RQ1 explored differences in the user need sets elicited from four different methods, which varied in terms of context (i.e., setting, questions). RQ1 represents a theoretical exploration of the framework as qualitative analysts, and not designers, identified user needs within nurses’ stories. In contrast, RQ2 represents an exploration of the practical impact of the framework during a design task. The purpose of RQ2 was to explore how the analysis instructions impacted design teams’ ability to identify user needs and document an identified design opportunity within a conceptual design.

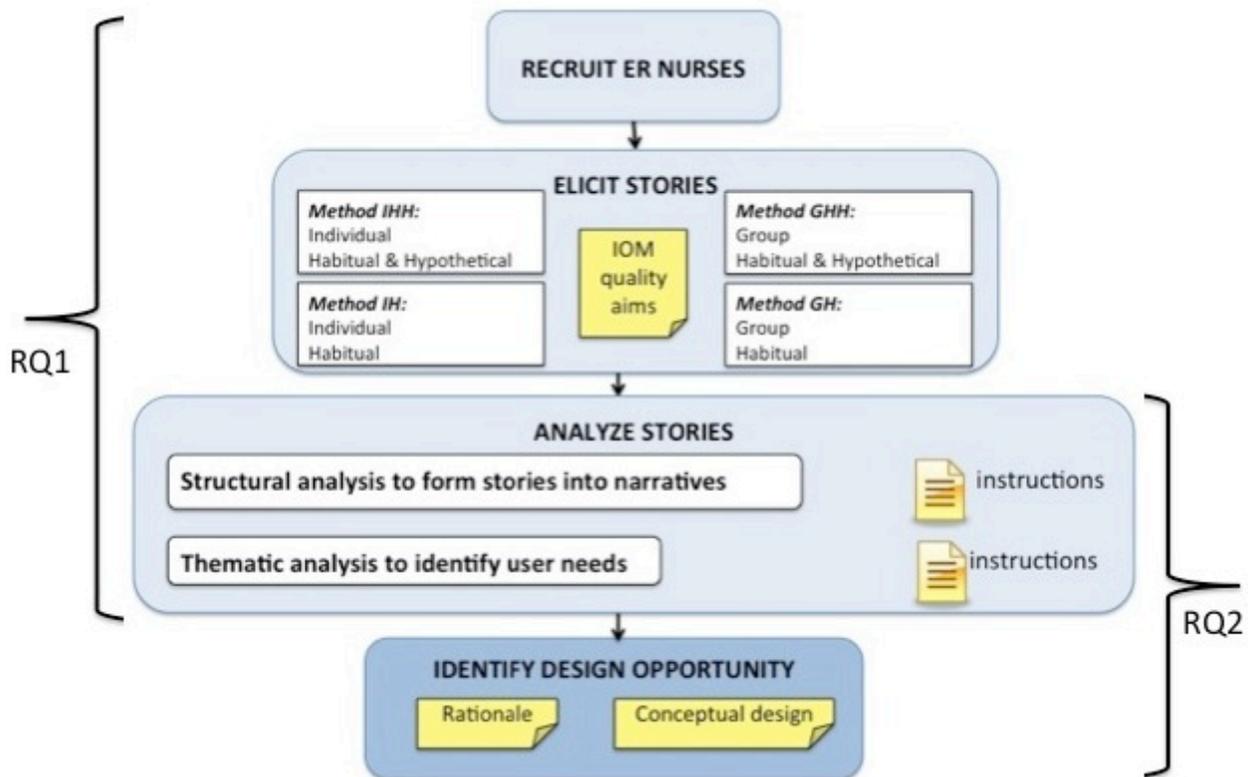


Figure 10. Components of the framework explored through the study's research questions

3.3.1.1 RQ1: What is the impact of the framework's different elicitation methods (i.e., IHH, IH, GHH, GH) on design?

Although RQ1 encompassed the first three stages of the Design + Storytelling framework, the focus of the exploration was the elicitation methods within the *Elicit Stories* stage. The creation of these four methods (i.e., IHH, IH, GHH, GH) facilitated exploration of how changes to the session context impacted the user needs contained within nurses' stories. The exploration was limited to changes in session setting and interview prompt, but additional changes to context could be explored in future work. Chapter 5 details the results for RQ1.

3.3.1.2 RQ2: What is the impact of the framework's analysis guidance on design?

The purpose of the RQ2 exploration was to determine if designers benefited from the instructions included within the *Analyze Stories* phase of the framework. Comparisons between design teams provided with the framework's instructions (i.e., W teams) and teams without (i.e., WO teams) were used to discern the impact of the instructions on design artifacts, including the identified user need set and resulting conceptual design for an identified design opportunity. Chapter 6 details the results for RQ2.

3.3.2 *Research approach*

To address the identified research questions, the research was conducted in three phases. RQ1 was addressed in Phases 1 and 2; RQ2 was addressed in Phase 3. In Phase 1 narrative analysts formed ER nurses' stories into narratives for subsequent analysis in Phase 2. Thematic analysts identified user needs within the narratives in Phase 2. In Phase 3, teams of student designers created conceptual designs that addressed an identified design opportunity informed by user needs identified within ER nurses' stories. Chapter 4, Chapter 5, and Chapter 6 present findings from Phase 1, Phase 2, and Phase 3, respectively.

CHAPTER 4. ELICITATION OF ER NURSES' STORIES (PHASE 1)

In the first phase of the research, we elicited ER nurses' stories using variations of the storytelling framework methods (Figure 8) discussed in Chapter 3. Analysts used structural analysis, a narrative analysis approach developed by Labov & Waletzky (1967), to transform these free-form stories into concise narratives. Narratives were operationally defined as “a representation of personal experience (i.e., a story) formed by content and structure”. The outputs of Phase 1 were: (1) a set of narratives, which were further analyzed in Phase 2 to identify user needs, (2) descriptive statistics (i.e., session duration, narratives collected) for the storytelling sessions, and (3) identification of factors that affect the session duration and quantity of narratives elicited as a result of the session.

All research documents relating to Phase 1 of this study are available in Appendix A. In addition, a glossary of terms, which provides all operational definitions used during this study, is available in Appendix D.

4.1 Method

The study employed a mixed methods approach. Participant responses during storytelling sessions were analyzed using structural and thematic analyses in Phases 1 and 2, respectively. In Phase 1, structural analysis of the transcripts resulted in a set of narratives, which became the data source for Phase 2 analyses (Figure 11). In Phase 2, thematic analysis of the narratives resulted in a set of user needs. After the qualitative analysis, statistical methods were used to investigate differences in the collected narratives and resulting user needs across treatment groups.

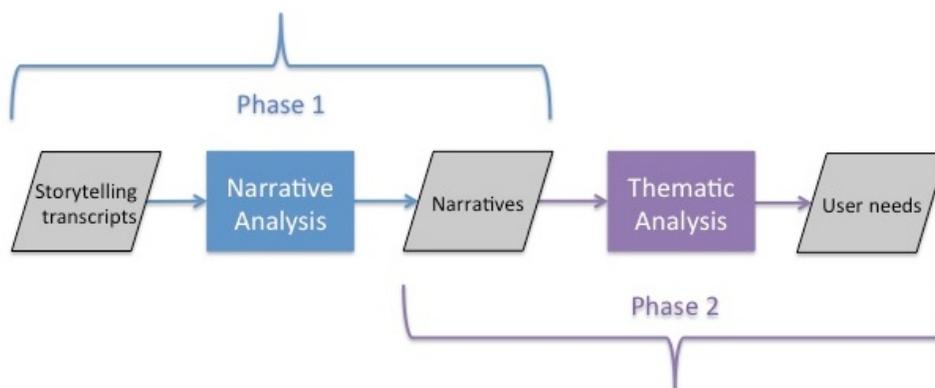


Figure 11. Qualitative methods used in Phases 1 and 2

Given the mixed methods approach, Phase 1 employed both qualitative and quantitative analyses. A team of analysts used structural analysis to form nurses' stories into narratives (See Section 4.1.8), which became the data set for Phase 2 analyses. A summary of the research design follows.

4.1.1 Summary of design – Phases 1 and 2

The original research design was a 2 x 2 (setting x questions) between-subjects design to allow for comparisons between treatments. This work was inspired by Garmer et. al.'s (2004) comparison of medical device requirements gathered via focus groups and usability tests. Participants were assigned to one of four groups based on demographic information, which was used to balance groups:

Group IHH: Individual storytelling sessions, habitual & hypothetical questions

Group IH: Individual storytelling sessions, habitual questions

Group GHH: Group storytelling sessions, habitual & hypothetical questions

Group GH: Group storytelling sessions, habitual questions

Although we originally expected all sessions to last approximately an hour, the range of session times was greater than we anticipated (See Section 4.2.1). To control for the potential confound of session time, we modified our original research design to include an additional predictor variable *session duration*, which was a categorical variable created by a quartile split (See Table 5). For example, storytelling sessions in the upper quartile were categorized as “long duration” and storytelling sessions in the lower quartile were categorized as “short duration”. All other sessions were categorized as “average duration”. This adjustment resulted in a 2 x 2 x 3 (setting x questions x duration) between subjects design. Table 5 details the dependent and independent variables for Phase 1 and Phase 2 of this study.

Inclusion of additional potential predictor variables in the model was not possible due to the limited number of observations (n = 22). Specifically, participant demographics (e.g., nursing experience, gender, age) are of interest in order to provide additional guidelines to designers for the recruitment of stakeholders. For example, in previous work (Gausepohl et al., 2011) we noted anecdotally that more experienced nurses expressed greater difficulty sharing stories than new nurses. Future work may explore associations between participant demographics and the information elicited during sessions.

Table 5. Dependent and independent variables for research phases 1 and 2

| | Description | Research Phase(s) |
|------------------------------|---|-------------------|
| Dependent variables | | |
| Narratives | Quantity of total narratives elicited | 1 |
| Habitual narratives | Quantity of habitual narratives elicited | 1 |
| Hypothetical narratives | Quantity of hypothetical narratives elicited | 1 |
| Session time | Time (minutes) of storytelling session | 1 |
| User needs | Quantity of user needs elicited | 2 |
| Functional needs | Quantity of functional needs elicited | 2 |
| Usability needs | Quantity of usability needs elicited | 2 |
| Effectiveness needs | Quantity of effectiveness needs elicited | 2 |
| Efficiency needs | Quantity of efficiency needs elicited | 2 |
| Satisfaction needs | Quantity of satisfaction needs elicited | 2 |
| Context-of-use needs | Quantity of context-of-use elicited | 2 |
| Activity needs | Quantity of activity needs elicited | 2 |
| Hygienic needs | Quantity of hygienic needs elicited | 2 |
| Physical needs | Quantity of physical needs elicited | 2 |
| Social needs | Quantity of social needs elicited | 2 |
| Spatial needs | Quantity of spatial needs elicited | 2 |
| Technological needs | Quantity of technological needs elicited | 2 |
| Breadth | Coverage of ontology categories | 2 |
| Independent variables | | |
| Setting | Two level categorical variable: <ul style="list-style-type: none"> • Individual storytelling sessions • Group storytelling sessions | 1, 2 |
| Questions | Two level categorical variable: <ul style="list-style-type: none"> • Habitual prompts • Habitual and Hypothetical prompts | 1, 2 |
| Session duration | Three level categorical variable <ul style="list-style-type: none"> • Long duration • Average duration • Short duration | 1,2 |

4.1.1.1 Statistical analyses of dependent quantitative variables in Phase 1 and Phase 2

Statistical analyses of the dependent quantitative variables was comprised of the following steps: (1) selection of an appropriate regression model (2) identification of main and

interaction effects and (3) testing for differences between groups. All statistical tests were conducted using Statistical Analysis Software (SAS) version 9.1.

4.1.1.1.1 Selection of regression model

Poisson regression, which utilizes a generalized linear model with a Poisson response and a link log (Cameron & Trivedi, 1998), was used to model all dependent variables of count data type (e.g., Narratives, User needs, etc...). The use of a Poisson regression model was appropriate as the assumption of homoscedasticity (i.e., constant variance) was not originally met, but was addressed through the log transformation. Linear regression was used to model the continuous dependent variable *session time* as the assumptions of linear regression were met (e.g., linearity, independence, homoscedasticity, normality) and the Shapiro-Wilk test indicated normality of session time, $p > .05$. The results of the Shapiro-Wilk tests and Fit Statistics for all Phase 1 dependent variables are provided in Table X. The statistics that guided the selection of the Poisson distribution for all Phase 2 dependent variables are provided in Appendix B.6.

Backward selection with an alpha level of 0.05 was used to determine which interactions and main effects to include in the model used for subsequent tests between groups. Differences were tested using the method of least square means with the Tukey-Kramer adjustment for multiple comparisons. The qualitative analyses in Phase 1 served two purposes. First, the results provided a consistency check for our assumptions of the storytelling activity. For example, as the group storytelling protocol included prompts directed at each participant, we expected to elicit more narratives during group sessions. Second, the results provided additional insight for the development of guidelines for the implementation of storytelling.

When a Poisson regression model was used, the following equations were used to calculate standard deviation ranges considering the log transformation of the data:

$$SD_{upper} = \exp(M^*) \exp(error) - \exp(M^*)$$

$$SD_{lower} = \exp(M^*) \exp(-error) - \exp(M^*), \text{ where } M^* \text{ is the least squares mean}$$

Table 6. Fit statistics for selection of Poisson distribution

| Dependent variable | Independent variables | Shapiro-Wilk Test for Normality (Pr < W) | Fit Statistics | | Selected Distribution |
|-------------------------|-----------------------|--|--------------------------------|--|-----------------------|
| | | | AIC | | |
| | | | Model w/ Normal Distribution | Model w/ Poisson Distribution Log Link | |
| Narratives | Setting | > .05 | 100.41 | 159.63 | Poisson |
| | Questions | | $\chi^2(10, n = 22) = 573.25$ | $\chi^2(10, n = 22) = 25.76$ | |
| | Setting duration | | | | |
| Habitual narratives | Setting | p = .01 | 141.50 | 142.6 | Poisson |
| | Questions | | $\chi^2(10, n = 22) = 245.50$ | $\chi^2(10, n = 22) = 14.30$ | |
| | Setting duration | | | | |
| Hypothetical narratives | Setting | p > .05 | 80.12 | 93.84 | Poisson |
| | Setting duration | | $\chi^2(5, n = 11) = 262.75$ | $\chi^2(5, n = 11) = 30.46$ | |
| Session time | Setting | p > .05 | 167.19 | 218.40 | Poisson |
| | Questions | | $\chi^2(18, n = 22) = 4591.95$ | $\chi^2(18, n = 22) = 88.38$ | |

4.1.2 Participants

Participants were 29 registered Emergency Room (ER) nurses working at one of four hospital locations within a corporate healthcare organization. Two hospital locations were mid-size city hospitals and two locations were small-size rural hospitals. In accordance with our confidentiality agreement with the healthcare organization, these four research site locations will be referred to as MC1 (i.e., Mid-size City 1), MC2, SR1 (i.e., Small-size Rural 1) and SR2, respectively. A purposeful sampling approach was used to select participants. Participant demographic information was used to balance participant assignments to each treatment group. For example, participants' workplace was considered during group assignments to ensure a similar mixture of rural and city participants (Figure 12). The balance between rural and city participants was considered due to expected differences in resources between city & rural hospital locations.

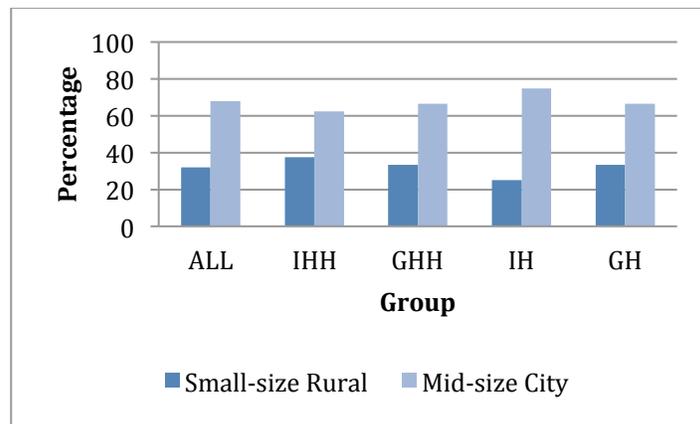


Figure 12. Participant workplace information

Since rural hospitals typically employ fewer staff and have limited access to equipment in comparison with metropolitan locations, it was anticipated that rural nurses would tell different stories than city nurses. For example, rural nurses may tell stories which reveal workarounds for dealing with a lack of access to computerized tomography (CT) scans, while city nurses may share stories which reveal problems utilizing the existing CT scan equipment. Overall, the majority of participants within each group worked at a small-size rural hospital, as participant recruitment was more successful at rural locations. Group IH contained the highest percentage

of rural participants (75%) in comparison with Group IHH (62.5%), Group GHH (66.7%), and Group GH (66.7%).

To ensure that each group represented the nursing population, participant assignments were bounded by demographic information for the registered nurse population published in “Findings from the 2008 National Sample Survey of Registered Nurses” (HRSA, 2008). For example, groups were predominantly female to match HRSA gender data (Figure 13). Group GHH contained 2 male participants, while all other groups only had 1 male participant. As a result, the GHH group differs the most from the HRSA data.

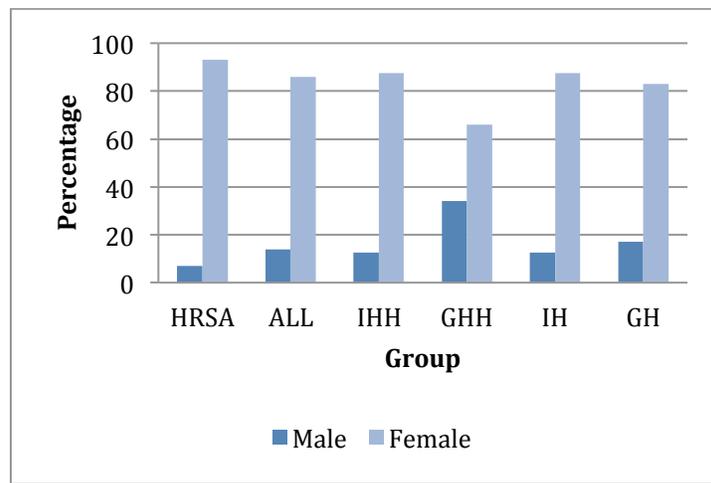


Figure 13. Group gender information compared with HRSA

Although we attempted to match age and experience within all groups to the HRSA data, some group assignments were more successful than others (Figure 14). For example, the GH group was comprised of younger participants ($M = 34$, $SD = 4.7$) with less experience ($M = 6.6$, $SD = 3.1$) than all other groups.

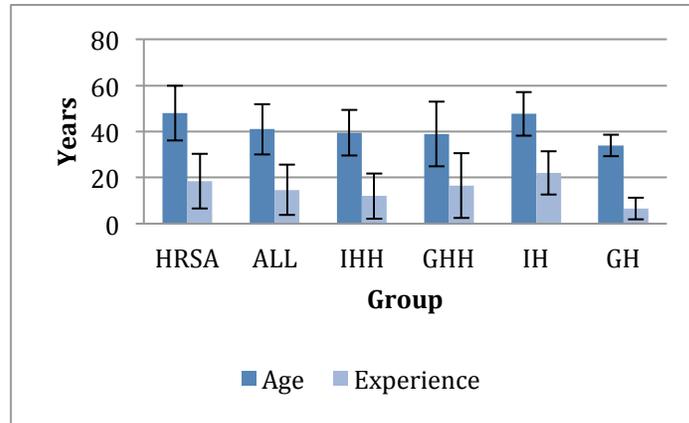


Figure 14. Participant demographic information compared with HRSA

Group sessions were particularly difficult to schedule due to nurses' 12-hour work schedules, which varied weekly and prevented scheduling of sessions with much advance notice. As a result, no willing group participant was excluded from the study, contributing to the unbalance of groups in terms of age and years-of-experience.

4.1.3 Recruitment

Initial contact with potential research sites was made after Virginia Tech IRB approval was obtained. Copies of the Virginia Tech IRB approval letter (Appendix A.1), the informed consent form (Appendix A.2), and the advertisement flyer (Appendix A.3) are provided in Appendix A. To retain the confidentiality of the institutions involved in this study, copies of each hospital's IRB approval letter are purposefully excluded from this document.

Although all research sites were governed by the same corporate healthcare organization, recruitment procedures at each location varied slightly to accommodate the unique culture within each site. In general, the recruitment strategy was to: (1) obtain a research champion within the ER department, (2) obtain IRB approval for each research location, (3) advertise study, and (4) schedule and conduct interviews.

4.1.4 Interview Materials

A demographic questionnaire was used to collect participants' age, gender, work location, and years of work experience (Appendix A.4).

The primary investigator followed a script (Appendix A.5) for all research sessions. All scripts included an introduction of the project, an overview of the informed consent process, an overview of storytelling, a reminder to abide by HIPAA guidelines, and a request for permission to audio-record the session. Group session scripts also included “ground rules” for the session, which included reminders not to dismiss the thoughts of other participants. All scripts contained habitual prompts, which asked participants to share experiences relating to an IOM quality aim (i.e., safe, timely, equitable, patient-centered, effective, and efficient care).

As the purpose of the storytelling session was to identify design opportunities within the emergency room, all habitual prompts were worded to elicit situations in which the quality aim was not achieved. Each script contained a total of eight story prompts. Since safe care and timely care affect both nurse and patient satisfaction, additional prompts were created to elicit stories from both perspectives. To explore possible design problems relating to safe care, participants were asked to share experiences where he/she felt patient safety was an issue as well as an experience where he/she felt that his/her own safety was an issue (Table 7).

Table 7. Example interview prompts

| IOM Quality Aim | Habitual Prompt | Hypothetical Prompt |
|-------------------------|--|--|
| <i>Safe Care</i> | Please tell me a story about an experience that you had where patient safety was an issue. | How would you re-write this story? For example, walk me through how this experience would have been in an ideal world. |
| | Please tell me a story about an experience that you had where you felt your own safety was an issue. | How would you re-write this story? For example, walk me through how this experience would have been in an ideal world. |

HH scripts (i.e., IHH, GHH) contained additional hypothetical question prompts, which asked the participant to retell how the recently related experience would have been in an ideal world.

4.1.5 Instrument

Sessions were recorded using an Olympus Digital Voice Recorder (Model #OLM WS110).

4.1.6 Procedure

Potential participants contacted the primary researcher via email or phone in response to study advertisements. During this initial contact, several potential interview dates and times were tentatively scheduled with the participant. Depending on availability of other participants at the same hospital location, the participant would be either assigned to an individual or group interview. Although we had originally planned to assign participants to group sessions based on demographic information, availability was the main factor used to assign participants to group sessions. All session rooms were scheduled via the designated hospital contact (e.g., ED manager, Nursing Education director, Clinical Care coordinator).

Participants were contacted via the indicated preferred contact method (e.g., email, phone) to confirm the session time and location. In addition, approximately 48 hours prior to the scheduled session, the primary investigator contacted participants with another reminder of the session date, time, location, and an overview of the IOM themes. This allowed participants to think of stories in advance, similar to Flanagan's (1954) CIT protocol.

Participant's informed consent was collected during the initial face-to-face meeting using informed consent forms (Appendix A.2). Participants assigned to individual sessions were assigned to either Group IHH or IH based on demographic information collected via questionnaire (Appendix A.4). Group participants were also assigned to either Group GHH or Group GH based on demographic information of the participant dyad.

Participants assigned to either Group IHH or Group IH participated in one individual storytelling session. Participants assigned to either Group GHH or Group GH participated in one group storytelling session with one other participant, who was a co-worker. Each session was scheduled to last 60 minutes to allow for 5 minutes for setup and 55 minutes for the actual storytelling session.

The primary researcher conducted all storytelling sessions. All sessions were conducted on the healthcare facility's campus to provide scheduling convenience and to reduce travel costs

for participants. Snacks and drinks were provided in an effort to create a cordial atmosphere and to facilitate discussion.

All digital audio files were downloaded from the audio recorder to a password protected USB drive within 24 hours of the session. After the download was verified, the original audio file was deleted from the digital recorder. In addition, all audio files were deleted after transcription.

4.1.7 *Structural analysis*

The purpose of the Phase 1 analysis was to form ER nurses’ stories (i.e., data collected during storytelling sessions) into concise narratives, which were then used as the primary data source in Phase 2. One benefit of structural analysis was that it facilitated data reduction. For example, participant responses that did not adhere to our operational definition of a narrative were identified during structural analysis and excluded from the data set. Structural analysis also facilitated data consistency. Participant responses, which were typically free-form recollections of events and experiences, were structured in a consistent format following Labov & Waletzky’s (1967) narrative components (e.g., abstract, orientation, complicating action, resolution, evaluation). Consistency in narrative structure facilitated thematic analysis in Phase 2.

The following sections describe the procedure used to transform participant responses into narratives. A summary of the people involved in Phase 1 is shown in Table 8.

Table 8. People involved in Phase 1

| Phase | n | Group | Description |
|--------------|----------|------------------|---|
| 1 | 29 | Participants | ER nurses working within one of four hospital locations that participated in storytelling sessions. One participant was used as a pilot and excluded from further analyses. |
| 1 | 6 | Narrative coders | Undergraduate students who restructured participants’ stories into concise narratives following Labov & Waletzky’s (1967) structural analysis approach. |
| 1 | 2 | Narrative Judges | Undergraduate students who facilitated reconciliation meetings with two narrative coders. |

4.1.7.1 Analysts

Three teams, each consisting of two coders and one judge, performed narrative analysis. The selection criteria for narrative analysts were: (1) a minimum of senior-level undergraduate academic status and (2) enrollment in an engineering, design, or computer science university program. One team (i.e., Team A) was comprised of 3 undergraduate computer science students participating in Virginia Tech's Research Experience for Undergraduates (REU) program. The remaining teams (i.e., Team B, Team C) were comprised of undergraduate student enrolled in the Industrial and Systems Engineering program at Virginia Tech. These four narrative coders participated in the project as part of a 3-credit undergraduate research course offered at Virginia Tech. The two remaining narrative judges participated in the research project on a volunteer basis.

Narrative coders independently structured free-form participant responses into narratives. For each response to a story prompt, coders ordered participant statements into narrative components following Labov & Waletzky's definitions for: (1) abstract, (2) orientation, (3) complicating action, (4) resolution, and (5) evaluation. Definitions for these structural components are available within the Glossary of Terms provided in Appendix D.

Since familiarity with narrative analysis methods was not a pre-requisite for analysts to participate in the research project, several training sessions were conducted to introduce analysts to the structural analysis protocol used in Phase 1. An overview of the training sessions is provided in Section 4.1.8.5.1.

4.1.7.2 Instrument

Analysts (i.e., coders, judge) used Microsoft Word to manage coding and reconciliation tasks. Each analyst used a 16GB SanDisk USB drive to store data and analysis files. Each team also used a private project site within Virginia Tech's course management system for file sharing.

Analysts were provided with detailed definitions for narrative components (Appendix A.6), narrative analysis instructions (Appendix A.7), an example analysis file (Appendix A.8), and a template for analysis results (Appendix A.9). Analysts were briefed on how to utilize these files during the initial training session (See Section 4.1.8.5.1). The definitions file summarized

the Labov & Waletzky (1967) definitions (e.g., abstract) and provided example statements for each component. The instructions outlined an iterative process for the transformation of participants' stories into ordered narratives. The example analysis file demonstrated individual iterations for the analysis of one habitual story and one hypothetical story. To retain confidentiality, all examples included in this document are fictional. However, the example file provided to analysts included analysis of actual stories collected during this study. The analysis template provided a tabular format for coders to paste participant statements and enter associated line numbers.

The coding judges were provided with instructions for running the reconciliation meetings (Appendix A.10), a reconciliation template containing all coder agreements (Appendix A.11), and a disagreement list used to initiate discussion and record final coding decisions (Appendix A.12).

Section 4.1.8.3 details the narrative analyses used in Phase 1.

4.1.7.3 Process

The narrative analysis process employed during this research project included both individual and group analyses (Figure 15). The first stage of the narrative analysis process was independent structural analysis of participant transcripts by two data coders within the analysis team. Using structural analysis, the two coders restructured practitioner stories into concise narratives. The coders met weekly as a group with a data-coding judge to reconcile the results. The purpose of the structural reconciliation meeting was to create a final agreed-upon narrative set, which would provide focus for later thematic analysis in Phase 2.

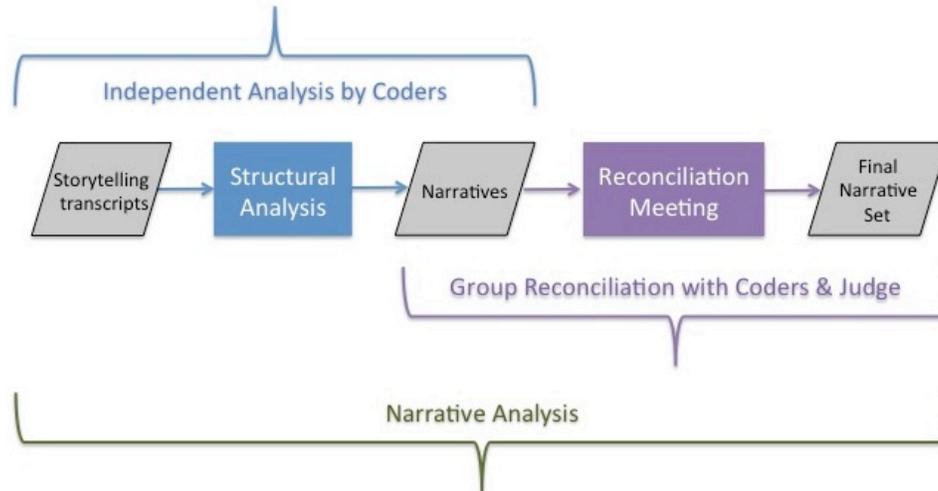


Figure 15. Narrative analysis consisted of independent and group analyses

The Phase 1 analysis process employed several strategies to encourage inter-coder reliability. In an effort to control for coding bias, two independent narratives coders analyzed participant stories without knowledge of the study’s research questions. Following Capra’s (2006) procedure, a coding judge recorded all agreements and disagreement during weekly reconciliation meetings. This information was used to calculate percent agreement scores as a measure of inter-coder reliability. Face-to-face training of the analysis procedures, which totaled over five hours, also encouraged inter-coder reliability.

Section 4.1.8.3.1 through Section 4.1.8.3.4 detail the analyses of habitual and hypothetical stories.

4.1.7.3.1 Structural analysis of habitual stories

Narrative coders initially read each habitual story in its entirety (Figure 16). The first step of the analysis was to identify the complicating action, which was operationally defined as “the plot”. The coders identified participant statements as part of the complicating action if the statement was either: (a) temporal sequence of event(s), (b) a “cause” in a cause/effect relationship, or (c) a description of conflict. If no complicating action statements were found, the coders terminated analysis since all habitual narratives by definition must have a complicating action (See Appendix D). In these instances, the participant’s response was categorized as “not a narrative” and was not included in further analyses in Phase 2.

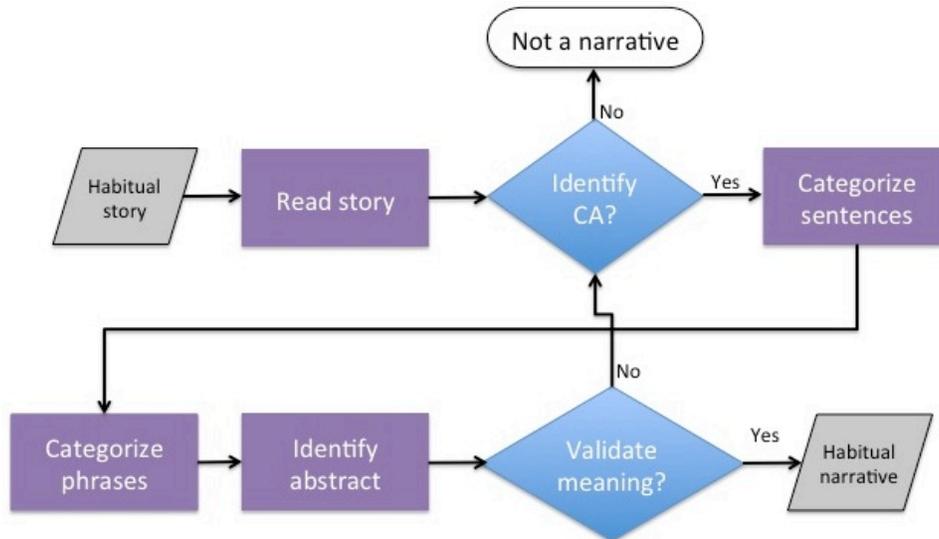


Figure 16. Process for structural analysis of habitual stories

After the complicating action was identified, coders copied the statements from the transcript to the habitual narrative framework under the *Complicating Action* heading. Coders included line numbers from the original transcript to allow for traceability and to simplify later reconciliation of results with team members. Coders initially categorized full sentences, which would later be analyzed at the phrase level since sentences could contain more than one narrative component.

Following identification of the complicating action, coders performed line by line analysis of all remaining full sentences within the habitual story. If the sentence matched one of the remaining narrative component definitions (i.e., abstract, orientation, resolution, evaluation), coders copied the sentence to the narrative template under the component heading deemed most appropriate. A full listing of the component definitions used during analyses is available in Appendix A.6. To retain the structure of the participant’s original story, coders ordered sentences by line number under each narrative component. If the sentence did not match one of the component definitions, it was excluded from further analyses.

Once all story sentences were analyzed, the coders continued working from the narrative template, which now contained full sentences categorized as narrative components. Starting at the beginning of the narrative template, coders categorized “phrases” into narrative components. A “phrase” was operationally defined as a “statement preceding a phrase break, such as the words ‘and’, ‘so’, ‘but’, and punctuation, such as commas, ellipses, and dashes.” Analysts moved phrases into other component categories as appropriate.

Following the analysis of phrases, coders reviewed the narrative template to identify an abstract, which was operationally defined as “a summary”. If an abstract was found, the analysts moved the phrase under the abstract heading in the template. Finally, the analyst validated the meaning of the narrative by re-reading both the original habitual story and the re-structured narrative. If the meaning of the original story was retained in the narrative, coders terminated with the acceptance of the habitual narrative. If the meaning was not validated, coders returned to the identification of the complicating action to trace the error in the analysis.

4.1.7.3.2 Example habitual analysis

A fictional story demonstrates transformation from participant’s stories to analyzed narratives (Table 9). A fictional story is used to retain both participant and research site confidentiality. A detailed description of the individual analysis steps for this fictional example is provided in Appendix A.8. Note that although the line order differs between the story and the narrative, the analyzed narrative retains the meaning of the original story.

Table 9. Example habitual story and resulting narrative

| Line | Habitual story | Habitual narrative |
|---|--|--|
| 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 | <p>Patient safety? Oh, man. I'll tell you about my worst day ever. I can actually remember the date, it was so bad. Man, was it bad. It was so bad that if I say, "My worst day" everyone in the ER knows what I am talking about. Anyway, there's an annual festival here that brings in a lot of out-of-towners. There's a lot of drinking at the festival. Let me ask you a question -what do you think you get when you add more people and more drinking to a town like this? You guessed it, a lot more people stumbling into the ER. And this isn't news to anybody. It's just how it works. So I'm working the last night of my 3 night shift and I'm already sort of burned out because the last 2 nights weren't any walk in the park, either. [Laughing] So I come in and I can tell from the day shift that they have had it rough so I already kind of have an inkling that this night is going to be a whopper. I start off by taking over 2 patients from day shift. Not a big deal – I can handle that. And then I don't know what happened, but it was like somebody let the gates open and we just got a flood of patients and I found myself with 4 bed patients and 3 hallway patients. Luckily, no one was critical, but I was still like, "I can't wait for this shift to end". Keep in mind that 3 ER patients are usually PLENTY to keep a nurse busy. 7 is just insane! But what can you do? You can't turn people away at the ER and the administration is so focused on productivity numbers and how quick we get patients from the front to the back. And to make it worse my patients were spread all over the place. I had 2 in the back rooms where you can't see anything, 2 in rooms by the nurses' station and 3 in the hallway. And one of the patients was a frequent flier with dementia and I was worried about not being able to keep a visual on [him/her]. Usually I would put this patient by the nurses' station for someone to watch, but everyone was just so bogged down with patients that there wasn't anyone available just to watch [him/her]. Luckily, nothing happened that night patient-safety-wise, but that was just sheer luck. We just didn't have enough staff to handle that influx of patients. Man, what a night. I felt like I was running a marathon the whole time running from patient-to-patient. When I left I never felt like coming back again. I am dreading the festival this year. I hope I'm not working that night. [Laughing]. We were really understaffed that day so I don't understand why administration doesn't give us the staffing we need.</p> | <p>Abstract 1 My worst day ever.</p> <p>Orientation 4 There's an annual festival here that brings in a lot of out-of-towners. There's a lot of drinking at the festival. Let me ask you a question - what do you think you get when you add more people and more drinking to a town like this? You guessed it, a lot more people stumbling into the ER. And this isn't news to anybody. It's just how it works. So I'm working the last night of my 3 night shift and I'm already sort of burned out because the last 2 nights weren't any walk in the park, either. 11 So I come in and I can tell from the day shift that they have had it rough so I already kind of have an inkling that this night is going to be a whopper. I start off by taking over 2 patients from day shift, which is no big deal - I can handle that. And then I don't know what happened, but it was like somebody let the gates open 34 We were really understaffed that day</p> <p>Complicating Action 15 and we just got a flood of patients</p> <p>Resolution 16 and I found myself with 4 bed patients and 3 hallway patients. 21 And to make it worse my patients were spread all over the place. I had 2 in the back rooms where you can't see anything, 2 in rooms by the nurses' station and 3 in the hallway. And one of the patients was a frequent flier with dementia and I was worried about not being able to keep a visual on [him/her]. Usually I would put this patient by the nurses' station for someone to watch, but everyone was just so bogged down with patients that there wasn't anyone available just to watch [him/her].</p> <p>Evaluation 1 I can actually remember the date, it was so bad. 2 It was so bad that if I say, "My worst day" everyone in the ER knows what I am talking about 16 Luckily, no one was critical, but I was still like, "I can't wait for this shift to end". Keep in mind that 3 ER patients are usually PLENTY to keep a nurse busy. 7 is just insane! But what can you do? You can't turn people away at the ER and the administration is so focused</p> |

on productivity numbers and how quick we get patients from the front to the back

28 Luckily, nothing happened that night patient-safety-wise, but that was just sheer luck. We just didn't have enough staff to handle that influx of patients.

31 I felt like I was running a marathon the whole time running from patient-to-patient. When I left I never felt like coming back again. I am dreading the festival this year. I hope I'm not working that night.

34 I don't understand why administration doesn't give us the staffing we need.

4.1.7.3.3 Structural analysis of hypothetical stories

Since hypothetical stories were told in a response to a follow-up prompt referencing a previously told habitual story (i.e., “Please tell me how that experience would have been in an ideal world.”), the habitual narrative was an additional input into the analysis process for hypothetical stories (Figure 17). First, coders copied the orientation, complicating action, and resolution from the habitual narrative into the hypothetical template, which created a framework for the hypothetical narrative.

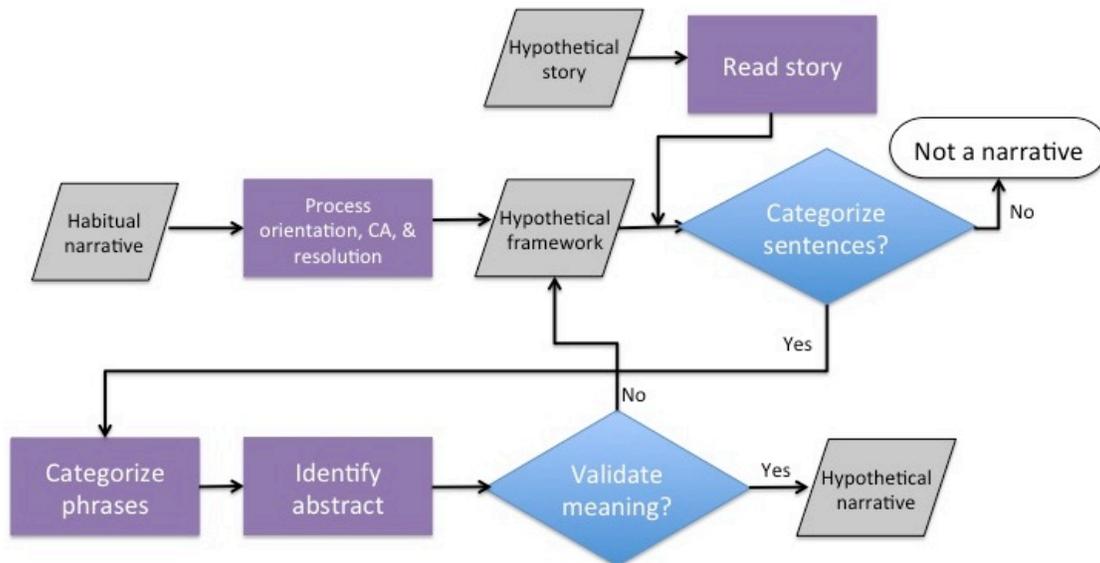


Figure 17. Process for structural analysis of hypothetical stories

Since the purpose of the hypothetical narrative is to demonstrate the gap between the current and desired work experience, these aspects of the habitual narrative were retained as a representation of the current work experience.

Coders then read the hypothetical story in its entirety. Starting from the beginning of the hypothetical narrative, coders copied full sentences to the narrative template under the component heading deemed most appropriate. The purpose of this step was to match up sentences that detailed the “ideal” experience with sentences or phrases that described the current experience to highlight the gap between them. Similar to the process for habitual narratives, coders then iterated at the phrase level and re-categorized phrases as needed. If coders identified a summary statement, the statement was moved to the *Abstract* category before validation of the narrative. To validate the narrative, coders re-read the hypothetical story and the hypothetical

story. If the meaning was retained in the hypothetical story, coders terminated and the hypothetical narrative was accepted. If the meaning was not retained, coders returned to the original hypothetical framework to trace the error.

A copy of the analysis instructions is available in Appendix A.7.

4.1.7.3.4 Example hypothetical analysis

A fictional hypothetical story, which compliments the fictional habitual story in Section 4.1.8.3.2, demonstrates the transformation of hypothetical stories into narratives (Table 10). The habitual narrative's orientation, complicating action, and resolution were used to construct the initial framework for the hypothetical narrative. Data re-used from the habitual narrative (i.e., participant statements and line numbers) is designated by plain text in the example. Data originating from the hypothetical story is highlighted in bold and italicized text. Hypothetical narratives were formed this way to highlight the gaps between the current and ideal situation to designers. A detailed description of the individual analysis steps for this fictional example is provided in Appendix A.8.

Table 10. Example hypothetical story and resulting narrative

| Line | Hypothetical story | Narrative |
|---|---|--|
| 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 | <p>In an ideal world? Like that exists. [Laughing]. First off, the festival isn't a new thing and we should know that we need more staffing that day. We have limited staffing, but they know we can't turn anybody away in the ER so better management of patient intake is necessary too. Don't just send everybody back to make productivity numbers. Anyway ideally weeks before the festival when they are determining staffing schedules, the administration would go, "hey, hold on a minute. Isn't the festival day usually a disaster in the ER?" [Laughing]. "Let's schedule more bodies so that we have enough people to handle the influx of patients that happens every year". And better yet, it would be great to prepare in advance for things that we know will be coming in. I know they have data for that. We keep data on everything. It seems to me that we have a lot of possible alcohol poisonings so in an ideal world we'd have the suction carts fully stocked and ready to go for those hall patients. But even with extra staffing it can still get overloaded. I think it would have been better that day if I didn't have to run around so much just to access my 7 patients. I could have handled them a lot better if they were at least in the same proximity. And if they can't be in the same general area, I need some way to check on patient's statuses without having to run in there all the time. Like some sort of tablet thing that kept me updated on the go. It could send me patients vitals and things like that. That way I wouldn't have to worry so much and stress myself out. It also doesn't help the patients to see how stressed out we are. So ideally, I'd like patients to see cool, calm, & collected nurses who are able to conquer the world! [Laughing] We have that at the nurses' station, but in frantic times no one is manning the nurses' station. We're all on the go. So basically, in my ideal world we'd have more staff and a better way to keep an eye on our patients.</p> | <p>Abstract 25 <i>In my ideal world we'd have more staff and a better way to keep an eye on our patients.</i></p> <p>Orientation 4 There's an annual festival here that brings in a lot of out-of-towners. There's a lot of drinking at the festival. Let me ask you a question -what do you think you get when you add more people and more drinking to a town like this? You guessed it, a lot more people stumbling into the ER. And this isn't news to anybody. It's just how it works. So I'm working the last night of my 3 night shift and I'm already sort of burned out because the last 2 nights weren't any walk in the park, either. 11 So I come in and I can tell from the day shift that they have had it rough so I already kind of have an inkling that this night is going to be a whopper. I start off by taking over 2 patients from day shift, which is no big deal - I can handle that. And then I don't know what happened, but it was like somebody let the gates open 34 We were really understaffed that day 1 <i>The festival isn't a new thing and we should know that we need more staffing that day. We have limited staffing, but they know we can't turn anybody away in the ER</i> 5 <i>Ideally weeks before the festival when they are determining staffing schedules, the administration would go, "hey, hold on a minute. Isn't the festival day usually a disaster in the ER?" [Laughing]. "Let's schedule more bodies so that we have enough people to handle the influx of patients that happens every year".</i></p> <p>Complicating Action 15 and we just got a flood of patients 3 <i>Better management of patient intake is necessary.</i> 4 <i>Don't just send everybody back to make productivity numbers.</i></p> <p>Resolution 16 and I found myself with 4 bed patients and 3 hallway patients. 21 And to make it worse my patients were spread all over the place. I had 2 in the back rooms where you can't see anything, 2 in rooms by the nurses' station and 3 in the hallway. And one of the patients was a frequent flier with dementia and I was worried about not being able to keep a visual on [him/her]. Usually I would put this patient by the nurses' station for someone to watch, but everyone was just so bogged down with patients that</p> |

there wasn't anyone available just to watch [him/her].

- 9 *It would be great to prepare in advance for things that we know will be coming in. I know they have data for that. We keep data on everything. It seems to me that we have a lot of possible alcohol poisonings so in an ideal world we'd have the suction carts fully stocked and ready to go for those hall patients.*
- 14 *I think it would have been better that day if I didn't have to run around so much just to access my 7 patients. I could have handled them a lot better if they were at least in the same proximity. And if they can't be in the same general area, I need some way to check on patient's statuses without having to run in there all the time. Like some sort of tablet thing that kept me updated on the go. It could send me patients' vitals and things like that. That way I wouldn't have to worry so much and stress myself out.*
- 22 *We have that at the nurses' station, but in frantic times no one is manning the nurses' station. We're all on the go.*

Evaluation

- 13 *But even with extra staffing it can still get overloaded.*
- 20 *It also doesn't help the patients to see how stressed out we are. So ideally, I'd like patients to see cool, calm, & collected nurses who are able to conquer the world!*
-

4.1.7.4 Reconciliation meetings

Coders met with the narrative judge during weekly reconciliation meetings. The use of a reconciliation meeting to compile results from independent coders in this study was based on procedures developed by Capra (2006). The purpose of the reconciliation meeting was to determine the master list of narratives that would be used as the primary data source in Phase 2.

Transcripts were randomly assigned to teams and reconciliation schedules were determined based on the length of each transcript. For example, some of the longer transcripts required two meetings to fully reconcile the results. Team A analyzed 7 transcripts, Team B analyzed 7 transcripts and Team C analyzed 8 transcripts.

4.1.7.4.1 Preparation for reconciliation meetings

In preparation for reconciliation meetings, coders uploaded MS Word files containing individual analyses to the online project site the day before scheduled meetings.

Since the Team B and Team C judges were volunteers, the primary researcher prepared all reconciliation files to reduce the time commitment for volunteers. The Team A judge prepared all reconciliation files since the judge received credit as part of Virginia Tech's REU program. To encourage consistency between the reconciliation files, the primary researcher and REU student followed a written procedure for creating reconciliation files (Appendix A.10) and used a template to record results (Appendix A.11).

In preparation for the reconciliation meetings, coders' narratives were compared line by line to identify discrepancies (Figure 18). All sentences and phrases with identical categorizations were included in the reconciliation template. All sentences and phrases that were not coded the same were included in the disagreement list. These two files were created to facilitate discussion during the reconciliation meeting.

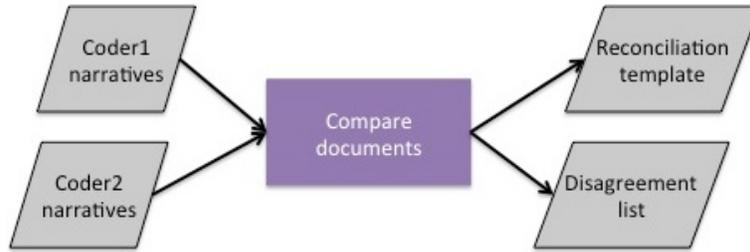


Figure 18. Coders' analyses were compared prior to reconciliation meetings

An example reconciliation template and disagreement list for the fictional example is provided in Appendix A.11 and Appendix A.12, respectively.

4.1.7.4.2 Reconciliation meeting process

The narrative judge facilitated all reconciliation meetings using the provided reconciliation template and disagreement list. To provide a context for the analysis, the analysts read each original story from the transcript prior to discussion of the narrative (Figure 19). The first item of discussion on the disagreement list was the complicating action, as the complicating action is the only required component for a narrative according to Labov & Waletzky's (1967) definition. If coders disagreed on the complicating action, discussion would initiate with the complicating action. Otherwise, the analysts would discuss the disagreements by line order.

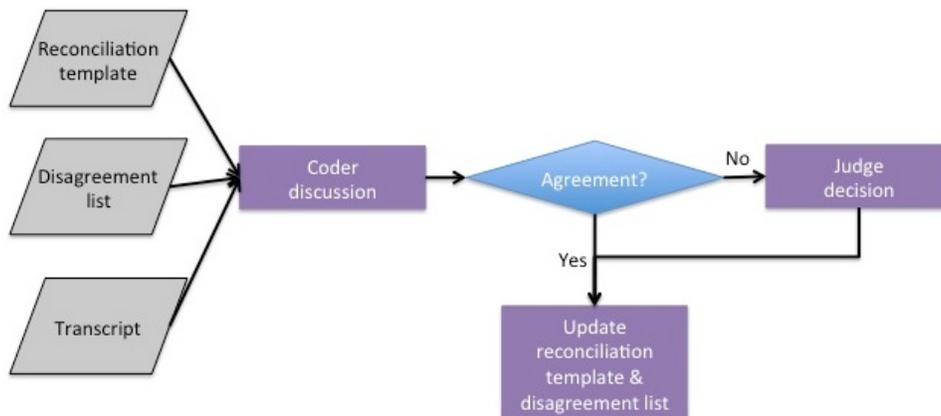


Figure 19. Reconciliation process

For each disagreement, coders explained the rationale behind his/her decision. The coders discussed the different interpretations with an end goal of finalizing a decision. In events where the coders were able to reach agreements, intervention by the judge was not necessary. The judge made final analysis decisions when the coders were unable to reach a mutual agreement.

The judge updated the reconciliation template as each reconciliation decision was made. In addition, the judge recorded the decision in the disagreement list for later inter-coder reliability analyses (See Section 4.1.8.5). After all disagreements were resolved, the analysts validated the newly created narrative through a comparison with the original story. If the narrative did not retain the original intent of the story, the analysts discussed prior decisions to identify the error in the analysis.

4.1.7.5 Inter-coder reliability

Inter-coder reliability per team was encouraged via training of coding procedures, which is described in Section 4.1.8.5.1. In addition, the agreement calculation per team allows for comparisons of inter-coder reliability between teams. The procedure for determining the agreement calculation, which was based on the procedure outlined in Kurasaki (2000), is described in Section 4.1.8.5.2.

4.1.7.5.1 Training

Each analysis team attended one 1-hour presentation led by the primary researcher, which provided an overview of the research project and qualitative analysis methods used in the project. The primary researcher did not reveal research questions to limit biases among analysts. To provide additional experience with narrative analysis, analysts were instructed to read Labov & Waletzky's (1967) introduction to narrative analysis prior to the next training session.

In addition, each analysis team attended one 2-hour training session, which provided an overview of narrative analysis as a method and the structural analysis instructions used during this study. The primary researcher facilitated group analysis of stories within a GHH transcript. This transcript was chosen because it allowed the team to practice analysis of both habitual and hypothetical narratives. In addition, since the transcript was from a group session, it allowed analysts to practice analysis with multiple speakers. The primary researcher guided the team through the step-by-step analysis instructions while one team member displayed the analysis results on a large screen display.

During the session, the primary researcher privately compared the team's analyses with the "ideal" coding results, which were created previously by the primary researcher as an

example analysis. When the team's categorization of a statement or phrase differed from the ideal analysis, the primary researcher interjected in the discussion and would ask team members to explain his/her decision rationale for why the statement did not belong in the other possible categories. Training was considered complete when analysts' analysis matched 80% of the ideal set. Team A, Team B, and Team C achieved competency at narrative 8, narrative 4, and narrative 5, respectively. All teams were provided with the example ideal coding file at the end of the session via the online project site.

The primary researcher attended the first reconciliation meeting to address any real-time questions about the process. At the beginning of this first meeting, the primary researcher gave an overview of the reconciliation template and the disagreements file to the narrative analysis judge. The primary researcher did not contribute during group discussion about disagreements as not to bias the results. The primary researcher observed the judge's competency in problem resolution to determine if any additional training was required. All team judges were deemed satisfactory at the end of the initial reconciliation meeting.

4.1.7.5.2 Coder agreement

A measure of inter-coder reliability was determined via Cohen's (1960) coefficient of coder agreement for nominal scales (i.e., Cohen's κ). Due to the sheer volume of qualitative data for participant responses in Phase 1, inter-coder reliability was calculated for a subset of the data (Kurasaki, 2000). Twenty narratives from each teams' analyses were randomly selected using the random number generator in MS Excel. The 20 narratives chosen represented roughly 10% of each teams' analyses since Team A analyzed 160 narratives, Team B analyzed 207 narratives, and Team C analyzed 170 narratives. As participant phrases were the unit of analysis for narrative coders, coder agreement was calculated at the phrase level. Coder agreement for each team was calculated before and after the reconciliation meeting (Figure 20).

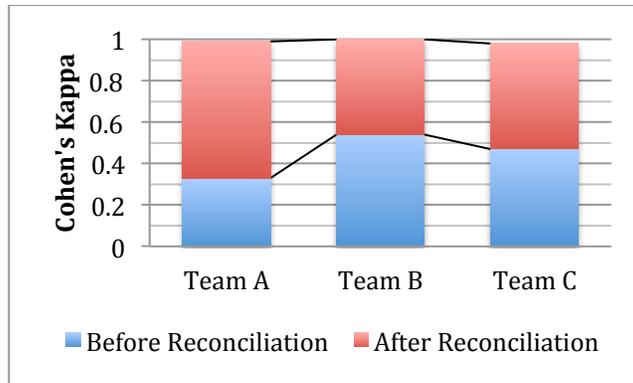


Figure 20. Percent agreement per narrative analysis team before reconciliation

Based on Landis & Koch’s (1977) guidelines for interpretation of Cohen’s coefficient, Team B ($\kappa_{\text{before}} = 0.54$) and Team C ($\kappa_{\text{before}} = 0.47$) had moderate agreement prior to reconciliation meetings; Team A had fair agreement ($\kappa_{\text{before}} = 0.33$). However, the reconciliation meetings improved the agreement score considerably. The reconciliation meetings improved Team A ($\kappa_{\text{after}} = 0.99$), Team B ($\kappa_{\text{after}} = 1.0$) and Team C’s ($\kappa_{\text{after}} = 0.98$) agreement to near perfect levels for the 20 randomly selected narratives.

4.2 Results

Twenty-nine ER nurses participated in a total of 23 storytelling sessions. The 23 interviews consisted of 17 individual sessions and 6 group sessions. The initial individual session was discarded prior to analysis to allow for modifications to the script. This resulted in the reduction of the data set to 28 participants in 22 sessions (i.e., 6 group, 16 individual).

4.2.1 Session time

Overall session times ($M = 54.9$ min, $SD = 19.8$ min) ranged from 28 minutes to 97 minutes (Figure 21).

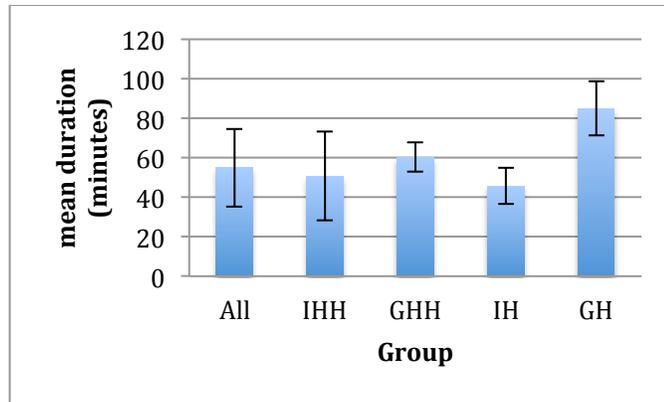


Figure 21. Mean session time per group

Group GH sessions ($M = 85.1$ min, $SD = 13.9$ min) had the longest duration and ranged from 70 to 97 minutes. Group GHH sessions averaged 60.4 minutes ($SD = 7.5$ min) and ranged from 55 to 69 minutes. Group IHH sessions averaged 50.7 minutes ($SD = 22.4$ min), with a range of 28 to 90 minutes. Group IH sessions had the shortest duration on average ($M = 45.7$ min, $SD = 9.1$ min), ranging from 35 to 61 minutes.

Session setting was identified as a main effect, $F(1, 18) = 10.3, p = .005$. Group storytelling sessions ($M = 72.7$ min, $SD = 4.2$ min) lasted significantly longer than individual storytelling sessions ($M = 48.2$ min, $SD = 6.8$ min), $t(20) = -3.06, p = .006$ (Figure 22).

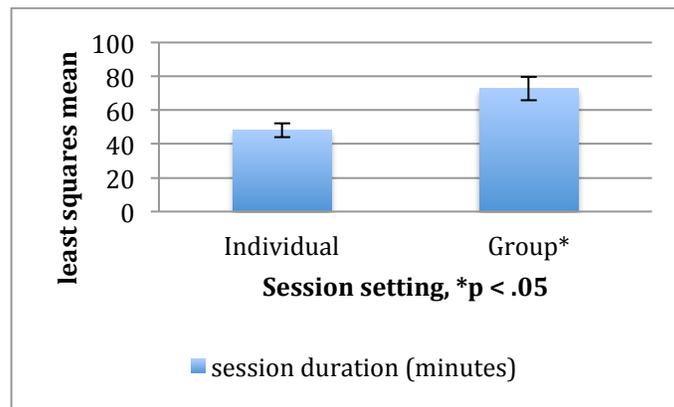


Figure 22. Differences in session duration by session setting

4.2.2 Narratives

A total of 573 narratives were elicited from 28 ER nurses as a result of this study (Figure 23). Of these, 441 were habitual and 132 were hypothetical. Comparisons between individual (i.e., IHH, IH) and group sessions (i.e., GHH, GH) must consider that 8 participants contributed narratives in individual sessions while only 6 participants contributed in group sessions.

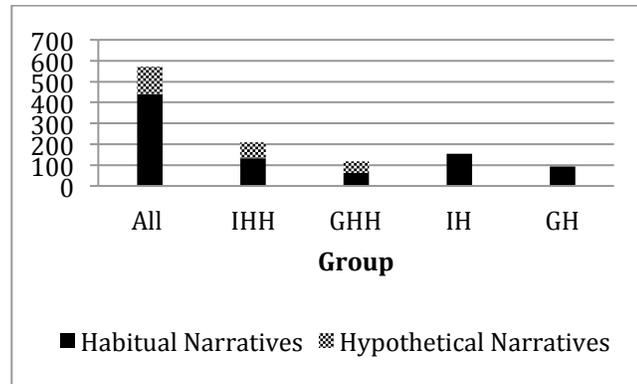


Figure 23. Total narratives elicited during this work

4.2.2.1 Total narratives

Group GHH ($M = 40$, $SD = 9$) participants shared the most narratives in comparison with other groups (Figure 24). Group IHH participants shared an average of 26 narratives ($SD = 8$), Group IH participants shared an average of 19 narratives ($SD = 8$), and Group GH participants shared an average of 31 narratives ($SD = 11$).

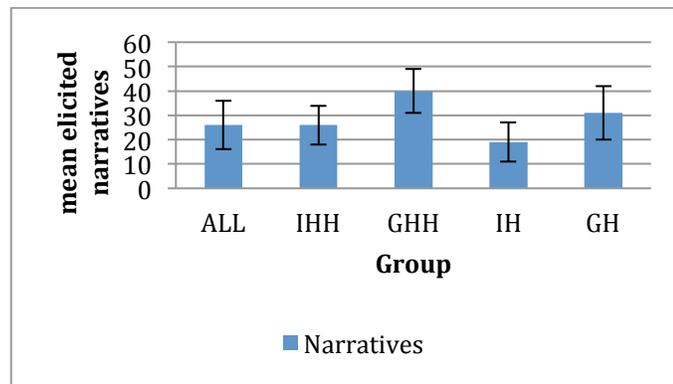


Figure 24. Mean elicited narratives per group

Session setting, questions, and time were identified as main effects for the quantity of total narratives elicited, $F(17) = 24.1, p = .0001$, $F(17) = 19.8, p = .0004$, and $F(17) = 8.7, p = .003$, respectively. No interaction effects were found to be significant.

Group sessions ($M = 34.1, SD = (1.2, 1.3)$) elicited significantly more total narratives than individual sessions ($M = 22.0, SD = (2.3, 2.5)$), $t(17) = 5.0, p = .0001$ (Figure 25).

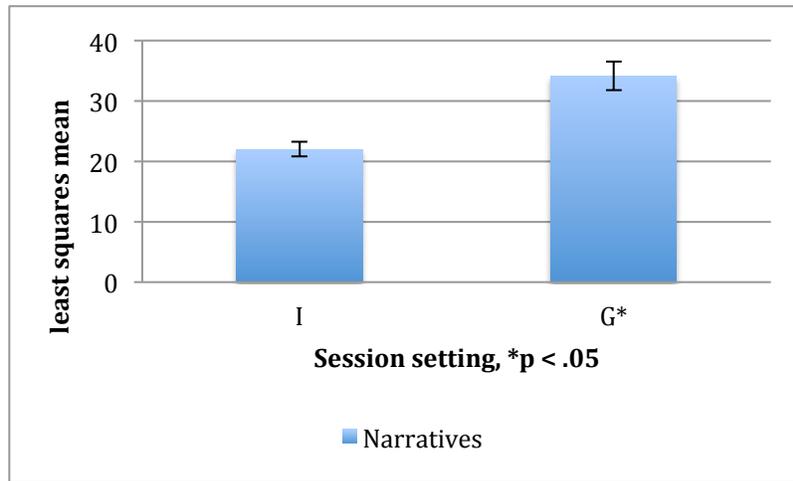


Figure 25. Total narrative differences by session setting

HH sessions ($M = 31.7, SD = (1.8, 1.9)$) elicited significantly more narratives than H sessions ($M = 23.7, SD = (1.5, 1.6)$), $t(17) = 3.5, p = .003$ (Figure 26).

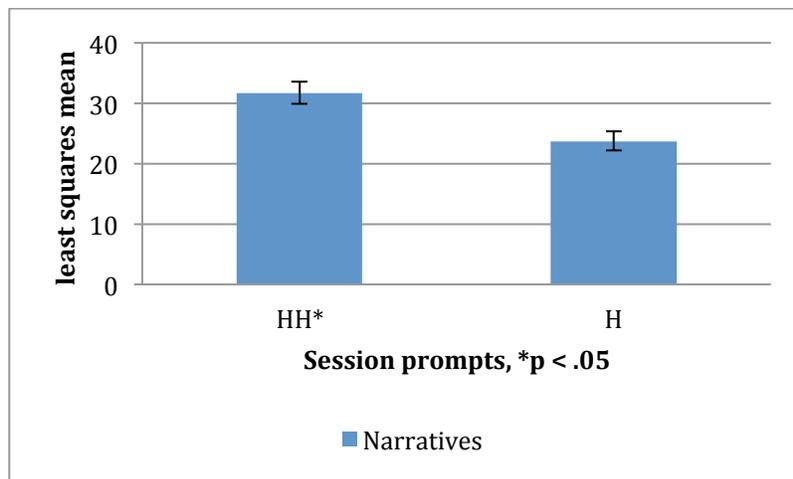


Figure 26. Total narrative differences by session prompts

Long duration ($M = 34.7$, $SD = (2.4, 2.6)$) sessions elicited significantly more total narratives than short duration ($M = 21.4$, $SD = (1.9, 2.0)$) sessions, $t(17) = 4.2$, $p = .002$ (Figure 27).

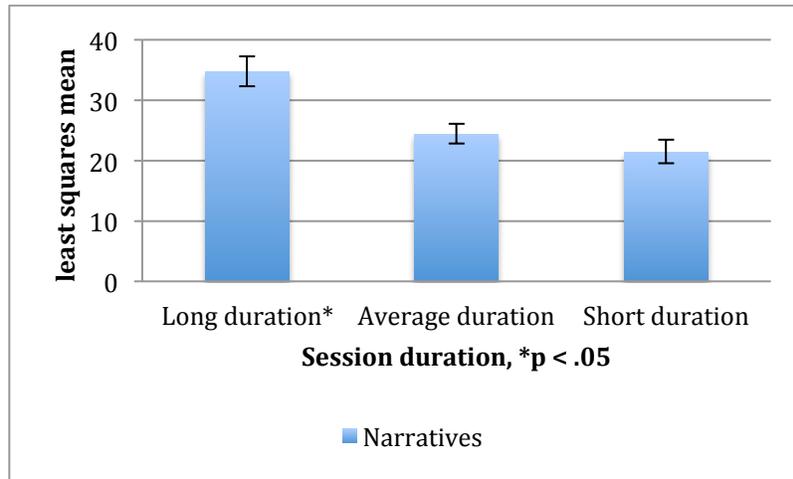


Figure 27. Total narrative differences by session duration

4.2.2.2 Total habitual narratives

On average, participants within group sessions contributed more habitual stories than those in individual sessions (Figure 28). Group GHH participants contributed an average of 40 habitual stories ($SD = 9$). Group IHH participants contributed an average of 26 ($SD = 4$) habitual stories. Group GH contributed an average of 31 habitual stories ($SD = 11$) and Group IH contributed an average of 19 habitual stories ($SD = 8$).

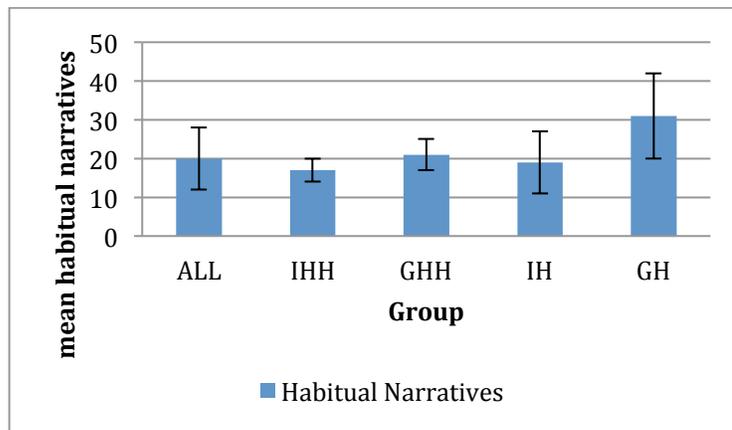


Figure 28. Mean habitual narratives elicited per group

Session setting, questions, and time were identified as main effects for the quantity of habitual narratives elicited, $F(1, 17) = 13.5, p = .002$, $F(1,17) = 5.4, p = .01$ and $F(2,17) = 7.8, p = .004$, respectively. No interaction effects were found to be significant.

Group sessions ($M = 25.3, SD = (2.0, 2.1)$) elicited significantly more habitual narratives than individual sessions ($M = 17.5, SD = (1.1, 1.1)$), $t(17) = 3.7, p = .002$ (Figure 29).

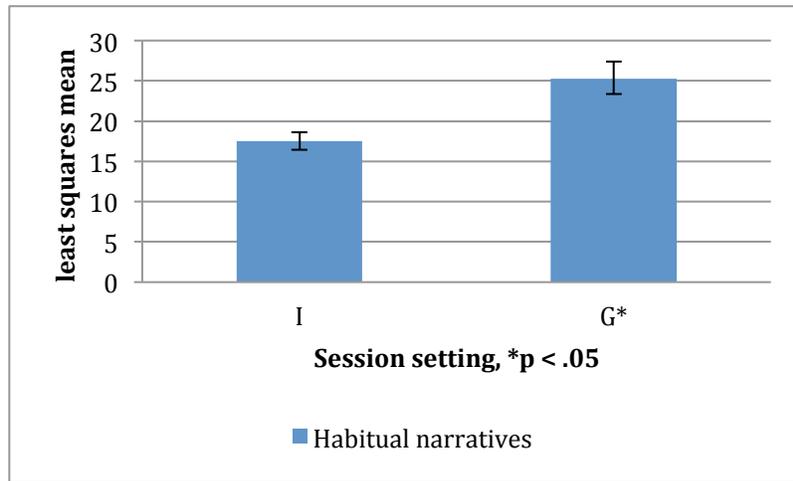


Figure 29. Habitual narrative differences by session setting

H sessions ($M = 23.5, SD = (1.3, 1.4)$) elicited significantly more habitual narratives than HH sessions ($M = 18.8, SD = (1.5, 1.6)$), $t(17) = 2.3, p = .03$ (Figure 30).

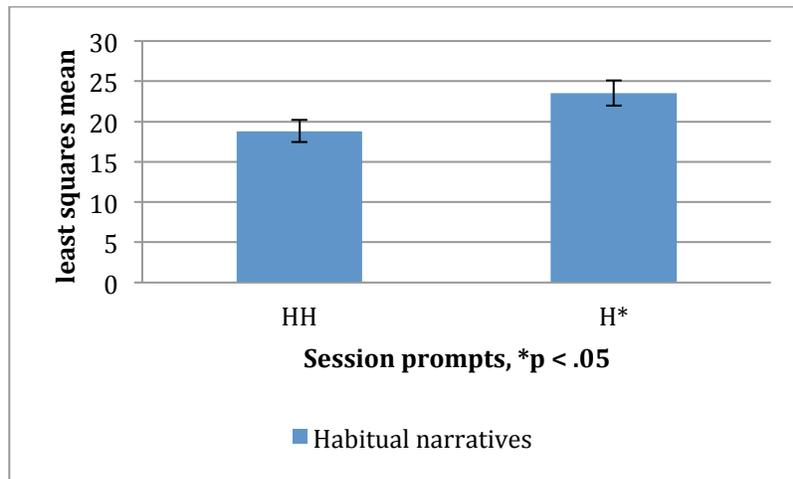


Figure 30. Habitual narrative differences by session prompts

Long duration ($M = 27.2, SD = (2.8, 3.1)$) sessions elicited significantly more habitual stories than short duration ($M = 16.5, SD = (2.0, 2.2)$) sessions, $t(17) = 3.9, p = .003$ (Figure 31).

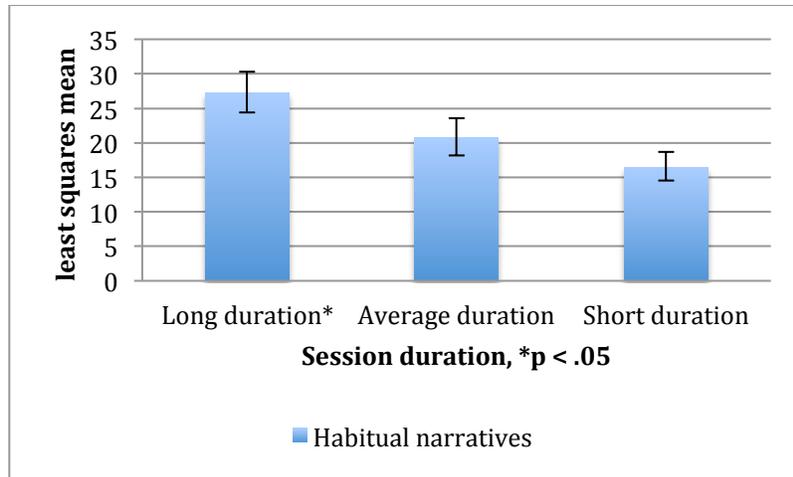


Figure 31. Habitual narrative differences by session duration

Analysis at the theme level reveals that on average Group GH participants contributed more total habitual narratives for all themes except for patient timeliness and efficiency (Figure 32).

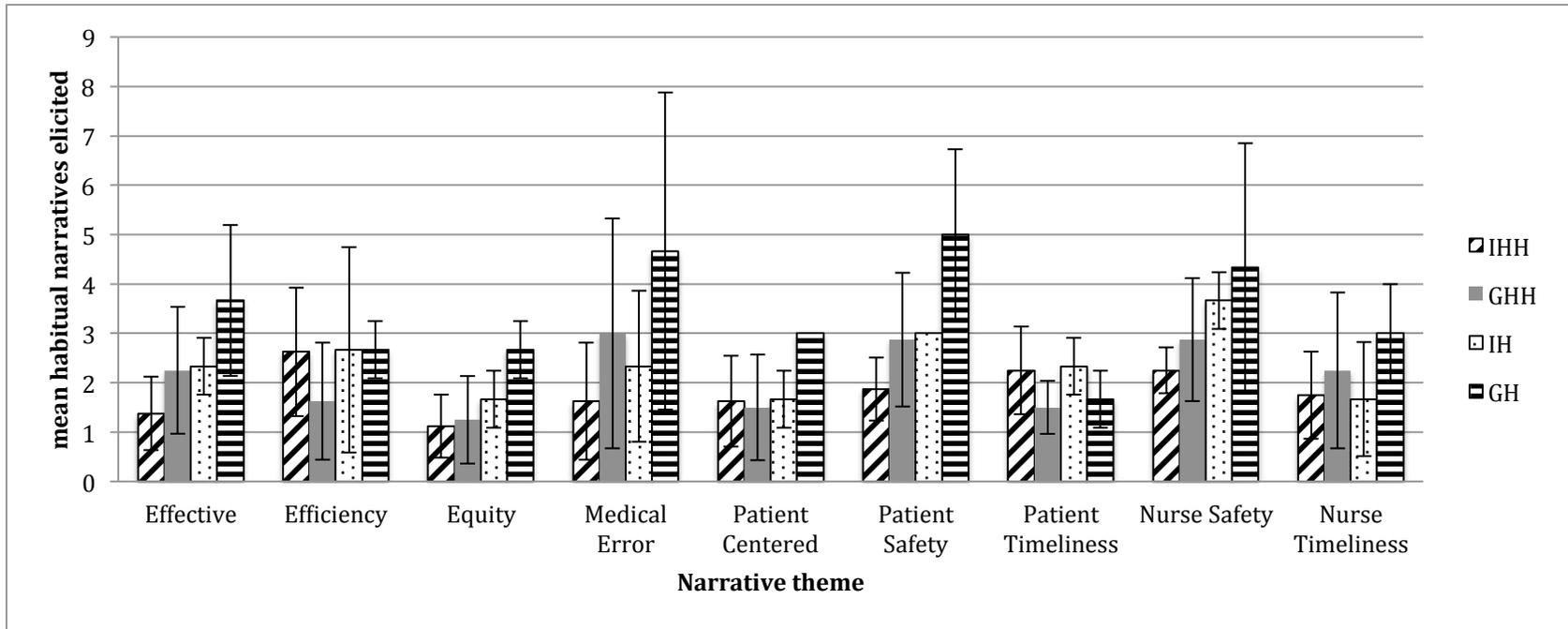


Figure 32. Mean habitual narratives per theme per group

4.2.2.3 Total hypothetical narratives

On average, Group GHH contributed almost twice the amount of hypothetical narratives as Group IHH (Figure 33).

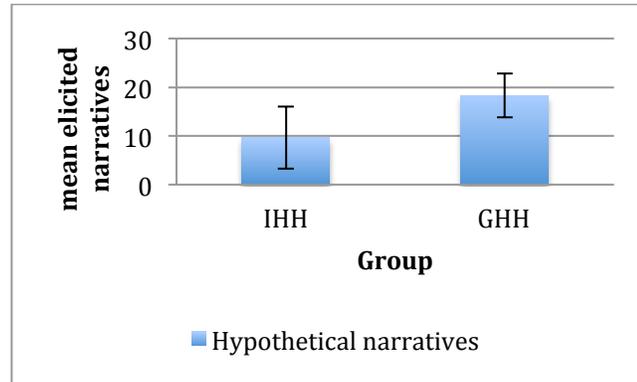


Figure 33. Mean elicited hypothetical narratives by group

Session setting was identified as a main effect for the quantity of hypothetical narratives elicited, $F(1, 9) = 13.3, p = .005$. No other main effects or interaction effects were found to be significant. Participants in group storytelling sessions also contributed more hypothetical stories than participants in individual sessions. GHH participants ($M = 18.3, SD = (-1.0, 1.2)$) contributed significantly more hypothetical stories than IHH participants ($M = 9.6, SD = (02.3, 2.6)$), $t(9) = 3.65, p = .005$ (Figure 34).

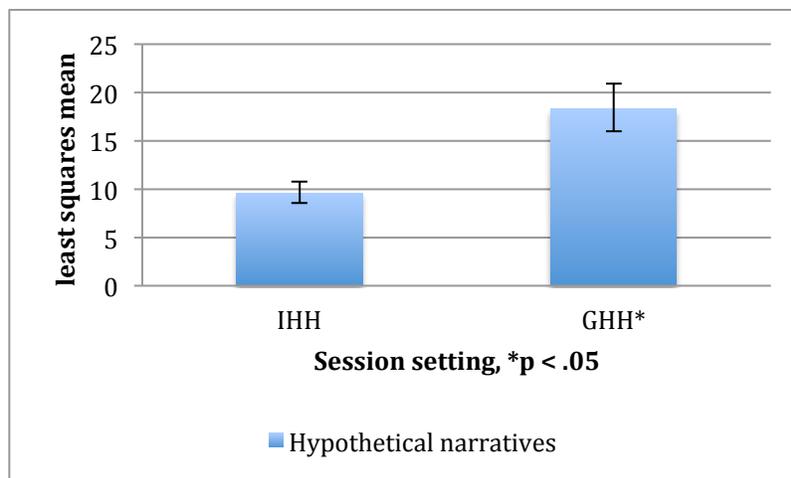


Figure 34. Differences in hypothetical narratives elicited by session setting

In terms of contributed hypothetical themes, Group GHH participants contributed more narratives for all other themes than Group IHH participants, on average (Figure 35).

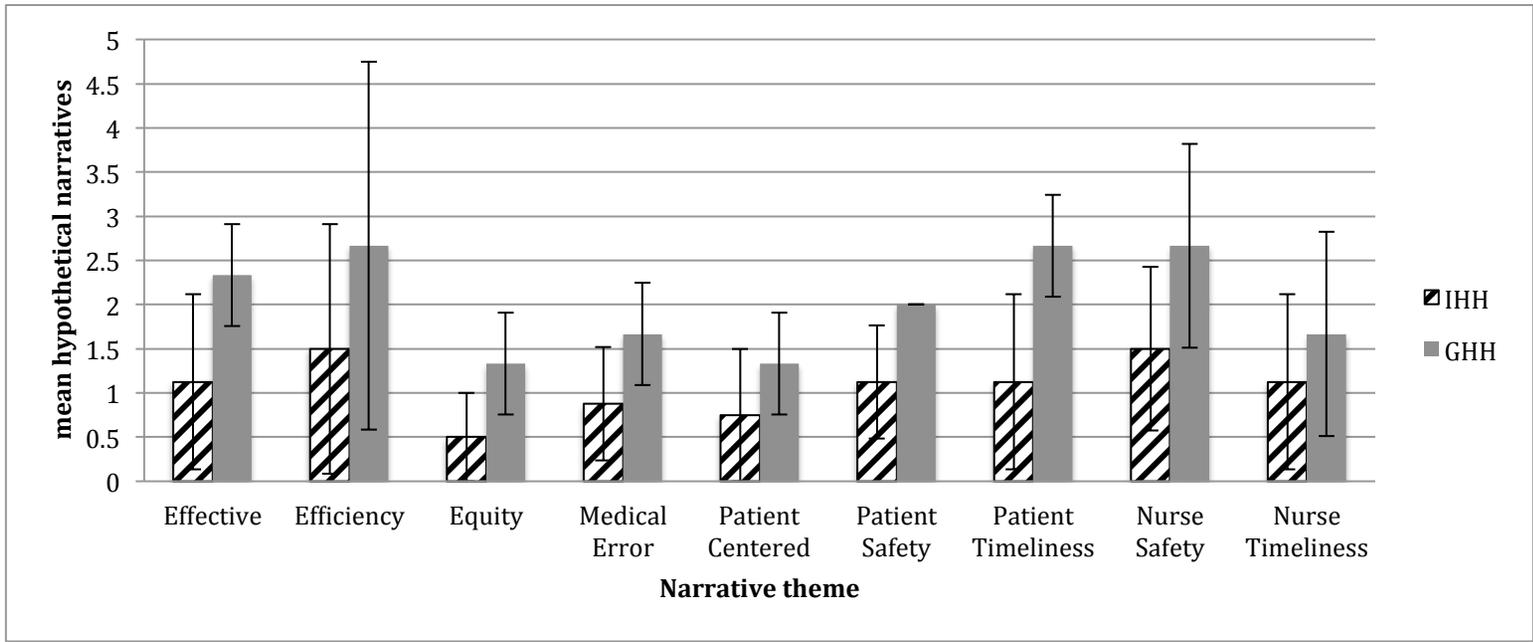


Figure 35. Mean elicited hypothetical narratives per theme, per group

4.3 Discussion

Preliminary analyses of the storytelling sessions and resulting narratives in Phase 1 resulted in several findings. First, the duration of group storytelling sessions was significantly greater than individual storytelling sessions. As group sessions prompted each participant to contribute a personal story for each IOM quality theme, a greater duration time was expected than when stories were collected from just one participant in individual sessions. Although an increased number of experimenter prompts within group sessions was expected to have contributed to the differences in session duration, we also suspect that the personal interaction between storytelling cohorts was an additional effect. While conducting these sessions we observed that participants in groups would encourage, prompt, and help co-construct stories with his/her cohort. One potential cause of the longer session times for groups may be this encouragement or prompting of storytelling by cohorts. Since the participants were coworkers in a teamwork environment that many participants described as “like a family”, it is likely that cohorts had either shared experiences or knowledge of experiences that allowed cohorts to prompt each other for information in a way that was not possible for an outside interviewer. For example, in response to a prompt about patient safety, one participant asked the other, “Are you going to tell her about the hallway patient?”, which prompted the nurse to divulge that story. Exploration of the impact of cohort prompting on session duration and/or elicited narratives is a potential direction for future work.

This finding does have important implications for designers, considering the difficulty in recruiting nurses to participate in a session that adds extra time to a 12-hour work shift. On average, group discussions ($M=72.7$ minutes) exceeded our advertised 1-hour session time, which excludes administrative tasks, such as completing after-session payments. In non-experimental settings, we recommend that designers either limit the number of story prompts to what can be comfortably answered within an hour or prioritize questions so that the most important story prompts are asked at the beginning of the session. This would allow more flexibility in the session and would reduce potential negative effects, such as participant fatigue towards the end of the session.

Not surprisingly, the total number of narratives elicited during sessions was impacted by setting, prompts, and time. Although these findings were expected, they do provide a consistency check for the logic behind our initial assumptions. Group sessions elicited

significantly more total narratives than individual sessions. Since two participants were prompted to share stories for each IOM quality aim, it was expected that group sessions would elicit more total narratives than individual sessions. We also anticipated that the addition of a hypothetical follow-up prompt to a habitual story would also result in more storytelling since participants would be asked to share two types of stories instead of just one. As expected, sessions employing habitual and hypothetical prompts (i.e., IHH, GHH) elicited significantly more total narratives than sessions employing only habitual prompts. The quantity of total narratives was also affected by session duration with longer sessions resulting in more total narratives than shorter sessions. Again, this is expected since storytellers should require more time to share more stories. However, the lack of significant differences in narrative quantity between long and average sessions suggests that there may be a difference in the types of narratives told. For example, if the total number of narratives is similar in both long and average duration sessions, what is cause of the need for additional time in the long duration sessions? Are storytellers in long sessions telling more detailed stories, which take more time to share? Or are these storytellers just naturally slower speakers than those in average duration sessions? Further exploration of the factors that impact session duration is another avenue for future work.

Differences in the total number of habitual narratives were also found for setting, questions, and session duration. Group sessions elicited significantly more habitual narratives than individual sessions, providing more support to the assumption that the inclusion of an additional participant would result in more stories told. Similar to the findings with total narratives, long duration sessions elicited significantly more habitual narratives than short sessions. Again, question prompts influenced the total number of habitual narratives elicited; sessions employing only habitual prompts elicited more habitual narratives than those with both habitual and hypothetical prompts. One possible and simple explanation for this difference is that the addition of the hypothetical prompt distracted time away from the collection of additional habitual stories.

This finding does have implications for designers. Consider a designer tasked with the identification of a design opportunity through exploration of the problem space. To ensure the identification of an appropriate design opportunity, the designer would want to collect as many narratives detailing various problems as possible. The results of this study suggest the use of habitual prompts exclusively would allow the designer to collect a greater quantity of habitual

stories to facilitate exploration of the problem space. Once the designer identified a design opportunity, the designer could conduct additional sessions including hypothetical prompts to further explore the desired idealized solution to the identified problem.

Although post-hoc analyses on factors impacting the collection of habitual narratives within particular IOM themes (i.e., patient centered) was outside the scope of this work, a preliminary analysis of the mean habitual narratives collected per theme, per group reveals several trends. On average, nurses shared more patient safety, medical error, and nurse safety stories than stories for other IOM themes. Several interpretations, which may be explored in future work, may explain this trend. The collection of more safety and medical error stories may be due to ordering effects, as these prompts were asked at the beginning of each session. The question prompts were purposefully ordered to facilitate discussion of medical devices, which was the topic of interest. In our first interview, which was later excluded and used as a pilot test, the participant expressed difficulty relating medical devices to some of the IOM quality themes (i.e., equitable care, patient-centered care) and expressed frustration until the topic shifted to safety concerns. In an effort to reduce the threshold for nurses' to become comfortable with storytelling, we began each session with topics relating to safety. In addition, this strategy allowed us to easily establish a discussion grounded in unmet design problems and medical devices before moving on to more "difficult" topics to relate to medical devices, such as, equitable care.

An alternative interpretation is that nurses may be more likely to share stories of medical error and safety because these are stories he/she has already shared. Narrative research suggests that previously disclosed stories are more likely to be shared again because the rehearsal of the events makes the event more accessible in long-term memory (Monisha Pasupathi, McLean, & Weeks, 2009). Since medical error and patient safety are concerns within healthcare, storytelling as a method may have facilitated the sharing of these hospital culture stories with an outside interviewer. Regardless of the reason for sharing, our elicitation of medical error and safety stories suggests that our protocol did successfully alleviate confidentiality concerns, as nurses shared stories that could implicate them professionally.

Analysis of the total quantity of hypothetical narratives revealed a factor effect for setting. Similar to findings for total and habitual narratives, group sessions (i.e., GHH) elicited a greater quantity of hypothetical stories than individual sessions (i.e., IHH). Again, this provides

further support for the assumption that the inclusion of an additional participant in group sessions would result in the collection of more stories. A preliminary analysis of the mean habitual narratives collected per theme, per group reveals that group sessions contributed more hypothetical stories for all story themes than individual sessions. Since group sessions elicited significantly more habitual stories, it logically follows that group sessions would elicit more hypothetical stories as hypothetical prompts were always asked in response to the sharing of a habitual story.

The findings of the post-hoc analyses in Phase 1 provide guidance for the identification of potential factor effects in later Phase 2 analyses, which are described in Section 5.2.3. Considering the significant differences in session duration and quantity of narratives between some groups, we created additional categorical variables for time, total narrative quantity, habitual narrative quantity, and hypothetical narrative quantity for use during Phase 2 analyses. These categorical variables were created based on upper and lower quartiles of the mean.

Chapter 5, which details the process used to identify user needs within ER nurses' narratives and post-hoc comparisons of the user needs elicited per group, follows.

CHAPTER 5. IDENTIFICATION OF USER NEEDS (PHASE 2)

The overall research question investigated in this work was, “How does the Design + Storytelling framework impact design?” The first research question (i.e., RQ1) investigated in support of this overall goal was, “What is the impact of the framework’s elicitation methods on design?” An empirical comparison of the user needs elicited via each of the methods provides critical design guidance given standards’ emphasis on the importance of user needs analysis. RQ1a guides the comparison between the framework’s four methods (i.e., Method IHH, IH GHH, GH). The supporting research questions for RQ1a addressed designers’ perspectives of an elicitation method’s “success”. RQ1a-1 investigated the impact of session context on the quantity of user needs elicited during the session. This information is valuable to designers when time or budgetary constraints limit the ability to conduct multiple sessions and the designer’s goal is to elicit as much information as possible within one session. RQ1a-2 and RQ1a-3 addressed the quality of the compiled user need set across all elicitation sessions. As in previous work, the quality of a user need set was evaluated in terms of breadth (i.e., coverage of user need categories) and depth (i.e., quantity of needs elicited within each category). The breadth and depth of the compiled set were investigated in RQ1a-2 and RQ1a-3, respectively.

The purpose of Phase 2 was to address RQ1. First, qualitative analysts identified user needs within the narratives collected during Phase 1 (See Section 4.2.2). These user needs were the source for the comparisons detailed in RQ1a-1 through RQ1a-3.

Section 5.1 provides an overview of the Phase 1 research questions.

5.1 Research Questions

RQ1: What is the impact of the framework’s elicitation methods on design?

RQ1a: What is the impact of storytelling session context (i.e., setting, questions) on the user needs elicited??

RQ1a-1: What is the impact of session context on the quantity of user needs elicited?

RQ1a-2: What is the impact of session context on the breadth of the compiled set?

RQ1a-3: What is the impact of session context on the depth of the compiled set?

5.2 Method

The 22 narrative transcripts created as a result of narrative analysis during Phase 1 were used as the data source for Phase 2. A mixed methods approach was used to address RQ1. Qualitative analysis methods were initially used to identify user needs within the narrative transcripts (See Section 5.2.1). Additional quantitative analyses on the quantity, breadth, and depth of identified needs were conducted to further explore RQ1 (See Section 5.2.3).

5.2.1 *Thematic analysis to identify user needs*

The purpose of this second phase was to address RQ1 through the identification of the complete set of user needs within each narrative transcript. This section first describes the data analysis method used for the identification of themes within the participants' narratives and the subsequent categorization of themes into a pre-existing ontology of usability requirements. This section then details the analyses for each of the Phase 2 research questions and associated hypotheses. A summary of the people involved in Phase 2 is shown in Table 11.

Table 11. People involved in Phase 2

| Phase | n | Group | Description |
|--------------|----------|-----------------|--|
| 2 | 2 | Thematic Coders | Identified themes within the narrative transcripts; categorized themes into a pre-existing ontology of usability requirements. |
| 2 | 1 | Thematic Judge | Determined which identified themes were valid and determined final categorization of themes. |

The ER nurses' narratives, which were collected via storytelling sessions of differing contexts (i.e., Methods IHH, IH, GHH, and GH), were the primary data source for Phase 2 analyses (Figure 36). The majority of the analysis for Phase 2 involved the identification & categorization of user needs within these narratives. The purpose of this analysis was to develop a master list of user needs and categorizations, which were then used to address RQ1.

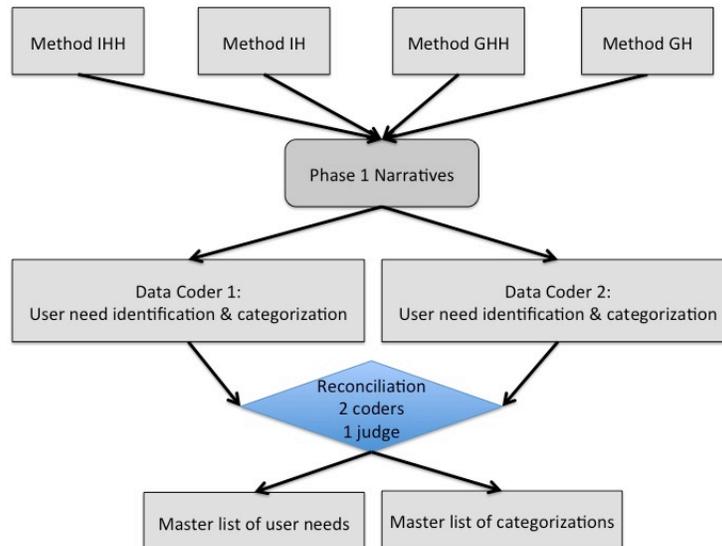


Figure 36. Summary of steps leading to theme identification

The Phase 2 analysis process employed several strategies to encourage inter-coder reliability, such as the use of two independent coders who analyzed data without knowledge of the study’s research questions, the assignment of a coding judge who facilitated coder discussion regarding disagreements during weekly reconciliation meetings (See Section 5.2.1.4), and initial training sessions on analysis instructions (See Section 5.2.2.1).

5.2.1.1 Analysts

The selection criteria for thematic analysts were: (1) a minimum of senior-level undergraduate academic status and (2) enrollment in an engineering, design, or computer science university program. Two graduate students enrolled in the Human Factors option within the Industrial and Systems Engineering program at Virginia Tech acted as thematic data coders. Data coders independently analyzed narrative transcripts to identify user needs and associated categorizations.

One undergraduate student enrolled in the Industrial and Systems Engineering program at Virginia Tech acted as a data coding judge. The data coding judge compiled coding results, managed weekly reconciliation meetings, and recorded coder disagreements for subsequent inter-rater reliability analysis.

Since familiarity with qualitative methods was not a pre-requisite for analysts to participate in the research project, several training sessions were conducted to introduce analysts

to the qualitative protocol used in this study phase. An overview of the training sessions is provided in Sections 5.2.2.1 and 5.2.2.2.

5.2.1.2 Instrument

Analysts (i.e., coders, judge) used ATLAS.ti version 6.2 qualitative analysis software to manage coding, categorization, and reconciliation tasks. Each analyst was given a 32GB SanDisk memory stick to store data and analysis files. A private project site was created within Virginia Tech's course management system, which was used for file management and sharing between analysts. Upon completion of analyses, the primary researcher downloaded all files and deleted the project site.

Analysts were provided with detailed instructions for the identification of user needs (Appendix B.1). The instructions outlined a 5-step procedure for the analysis of individual narratives. The instructions also provided definitions for user need categories, as well as formatting guidelines for the specification of each identified user need.

The coding judge used a template to record coding disagreements and final coding decisions (Appendix B.3).

A detailed explanation of the analysis process used in Phase 2 follows.

5.2.1.3 Process

The overall process for user need identification was based on previous work which explored the efficacy of storytelling as an elicitation method for medical device design (Gausepohl et al., 2011). This process was based on the block and file approach to thematic analysis described in Grbich (2007). Thematic analysis is a technique used in content analysis where themes emerge from participant transcripts after repeated readings and iterative comparisons. In the block and file approach, coders tag statements into chunks and then categorize these chunks into meaningful groupings. Similarly, coders in Phase 2 were instructed to tag statements into "user need themes" (chunks) and then categorize these themes into the meaningful groupings already described by the pre-existing ontology.

The ontology used in Phase 2 was also created in previous work (Gausepohl et al., 2011) to provide a framework for the categorization of user needs into requirements categories specific to medical devices (Figure 37).

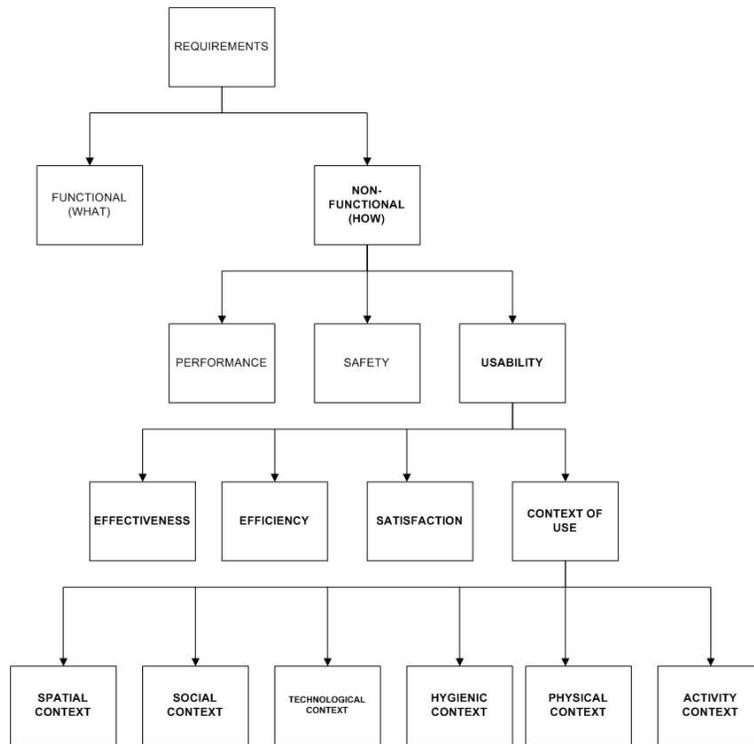


Figure 37. Requirements ontology used during theme identification

It is important to note that one user need can be associated with more than one category within the ontology. For example, the identified user need “protect staff” was categorized as both a functional need and as a satisfaction need. It was categorized as a functional need because it described what the system and/or worker needed to do. It was also categorized as a satisfaction need because nurses expressed dissatisfaction with working in hazardous conditions.

This ontology was adapted by expanding requirements categories identified in the literature (Arthur, 2007; Chung, Nixon, Yu, & Mylopoulos, 1999) to include context-of-use requirements specific to medical devices identified in IEC 62366. Since the focus of the research project was the elicitation of usability requirements, the ontology was expanded to further categorize usability requirements using both the ISO 9241-11 definition of usability and the definition within ANSI/AAMI HE74.

Adaptations were made to the analysis process used in previous work in an effort to refine the process and to address lessons learned. First, since the data source for Phase 2 were

concise narratives, coders were instructed to iterate at the narrative level and at the transcript level. Since grounded theory methods emphasize the importance of constant comparisons, the inclusion of additional comparisons at the narrative level strengthens the analysis from a qualitative perspective. In previous work, coders iterated at the transcript level since the data source (i.e., focus group, interview, and storytelling responses) could not be transformed into concise narratives. Second, grammar rules for the specification of user needs were included to encourage consistent user needs within and between coders (Gausepohl, Beaton, & Winchester, 2011). The grammar rules provided linguistic structures to encourage the creation of consistent and specific user needs (Figure 38).

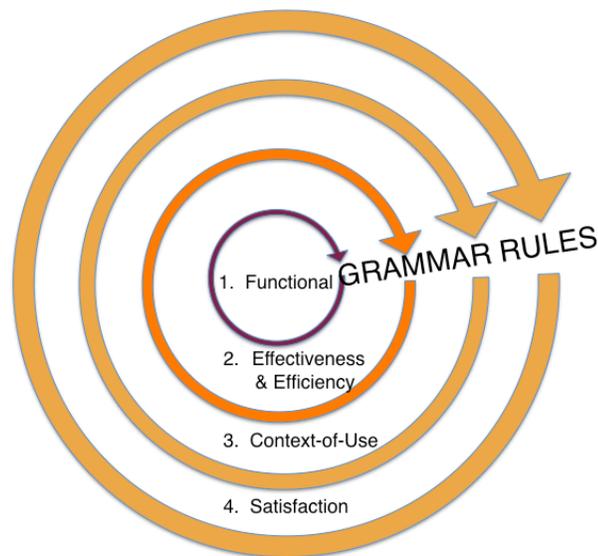


Figure 38. Grammar rules guide identification and specification of user needs

A noted frustration in previous reconciliation meetings was perceived difficulty in comparing similar user needs that were specified using slightly different language. In addition, the use of inconsistent phrasing made it difficult for coders to keep track of existing codes and categorizations. The constraints invoked by the grammar rules encouraged consistency in user need specification, which in turn reduced within-coder confusion caused by inconsistent specifications. The improved consistency between coders also facilitated easier reconciliation meetings, as similar user needs were easier to identify by their common grammar.

5.2.1.3.1 Data coder identification of user needs

Data coders followed an iterative 5-step process for the identification and specification of functional and usability user needs within each individual narrative. The 5-step process was:

- (1) Read individual narrative
- (2) Identify functional user needs
- (3) Identify effectiveness and efficiency user needs
- (4) Identify context-of-use user needs
- (5) Identify satisfaction needs

The steps within the identification process were informed by the requirements ontology (Figure 37) used in this study. Since usability needs describe the desired features of functional needs, these needs were identified first to facilitate discovery of usability needs. Once the functional needs were identified, analysts searched for effectiveness and efficiency needs, which are components of usability according to the ontology. In the fourth iteration, further explored usability through the identification of context-of-use needs. Identification of the final component of usability, satisfaction, was delayed until the last iteration to encourage the identification of outliers that would truly impact the acceptability of the design. This strategic delay allowed analysts to identify a user need set first and then select key needs critical for satisfaction from the set.

After reading each narrative, coders followed grammar rules in subsequent iterations to specify identified user needs. Table 12 details the grammar rules used within iterations, which instilled a hierarchical approach to user needs specification.

Table 12. Example usability needs associated with the functional need *monitor patients*

| Iteration | Grammar Rule(s) | Example |
|-------------------------------|--|--------------------------------|
| 2. Functional | Active verb + object | Monitor patients |
| 3. Effectiveness & Efficiency | [Rules in Iteration 2] Active verb + object + prepositional phrase Active verb + object + adverb | Monitor patients wirelessly |
| 4. Context | [Rules in Iterations 2 - 3] Object + adjective Gerund + prepositional phrase Gerund + adjective | Working with multiple patients |
| 5. Satisfaction | [Rules in Iterations 2 - 4] | Monitor patients wirelessly |

Following this hierarchy, a need identified in Iteration 2 could be included within categories occurring in later iterations without changes to the grammar. For example, the efficiency need “monitor patients wirelessly”, which was initially specified in Iteration 3, was also categorized as a satisfaction need without any changes to the grammar. Conversely, needs specified in later iterations required changes to the grammar in order to be associated with categories occurring in earlier iterations. For example, if a coder decided to categorize the Iteration 4 need “working with multiple patients” as an effectiveness need as well, its specification would need to be changed to fit the Iteration 3 grammar rules. This could be easily accomplished by changing the specification to “monitor patients in multiple locations”. This rephrased need, which follows the [active verb + object + prepositional phrase] grammar rule in Iteration 3, now adheres to the hierarchical grammar, making the categorizations in both effectiveness and context categories valid.

An overview of the process for the identification, categorization and specification of user needs follows.

5.2.1.3.2 Identify and specify functional needs

Initially, functional needs within each narrative were identified and specified according to the process’ grammar rules. For example, each functional need was worded to complete the phrase “the system and/or worker shall:” using the linguistic structure [active verb + object] (Table 13). Functional needs were further refined in subsequent iterations to identify associated

usability requirements, which were also formed following the process’ grammar rules. The grammar rules varied between iterations to encourage increased specificity.

Table 13. Definition and grammar rules for functional user needs

| | |
|-------------------|--|
| FUNCTIONAL | States the functional need – the “WHAT” |
| DEFINITION | What the worker or current/needed system needs to do The worker shall _____ The system shall _____ |
| GRAMMAR | Active verb + object |

5.2.1.3.3 Identify and specify effectiveness and efficiency needs

In the next iteration, coders analyzed previously identified functional requirements to identify associated effectiveness and efficiency needs (Table 14). The linguistic structure previously used for functional requirements was expanded to encourage increased specificity.

Table 14. Definition and grammar rules for effectiveness and efficiency needs

| | |
|----------------------|---|
| | Describes the functional need – the “HOW” |
| EFFECTIVENESS | Level of <u>accuracy</u> & <u>completeness</u> in which a user is able to satisfy goals (ISO, 1999) |
| EFFICIENCY | Amount of <u>resources</u> used to achieve goals (ISO, 2000) |
| GRAMMAR | Active verb + object + <i>prepositional phrase</i> Active verb + object + <i>adverb</i> |

For example, effectiveness & efficiency requirements extend the functional requirement using a linguistic structure, such as [active verb + object + adverb] or [active verb + object + prepositional phrase].

5.2.1.3.4 Identify and specify context-of-use

In the next iteration engineers explored the context in which the functional needs occurred. The context-of-use with a healthcare design problem may include aspects of the

activity, hygienic, physical, social, spatial, and technological context (Table 15). Contextual needs were specified using [object + adjective], [gerund + prepositional phrase], and [gerund + adjective] linguistic structures.

Table 15. Definitions (IEC, 2007) and grammar rules for context-of-use needs

| | |
|---------------|---|
| | Describes in what context the functional need occurs |
| ACTIVITY | Aspects of the task activity (e.g., distractions, workload, fatigue) that may impact ability to satisfy goals |
| HYGIENIC | Cleanliness / sterile conditions required to satisfy goals |
| PHYSICAL | Aspects of the physical environment (e.g., light and noise level) |
| SOCIAL | Aspects of the organizational environment (e.g., responsibility, hierarchy) |
| SPATIAL | Aspects of the spatial environment (e.g., mobility, architectural layout) |
| TECHNOLOGICAL | Other technologies used / required to satisfy goals |
| GRAMMAR | Object + adjective Gerund + prepositional phrase Gerund + adjective |

5.2.1.3.5 Identify satisfaction needs

In the final iteration coders identified new & existing needs from previous iterations that impact the perceived acceptability of the design solution (Table 16). These needs were then categorized as satisfaction needs. Satisfaction needs were specified using any of the valid grammars for Iterations 2 – 4.

Table 16. Definition (ISO, 1999) and grammar rules for satisfaction needs

| | |
|--------------|---|
| SATISFACTION | Perceived <u>comfort level</u> and <u>acceptability</u> while working towards goals |
| GRAMMAR | See Iterations 2 - 4 |

5.2.1.4 Reconciliation Meeting

Coders met weekly with a data coding judge to reconcile their independent coding results (Figure 39). The use of a reconciliation meeting to compile results from independent coders in this study was based on procedures developed by Capra (2006). The purpose of the thematic

analysis reconciliation meeting was to identify a master list of themes per narrative and a master list of categorized themes.

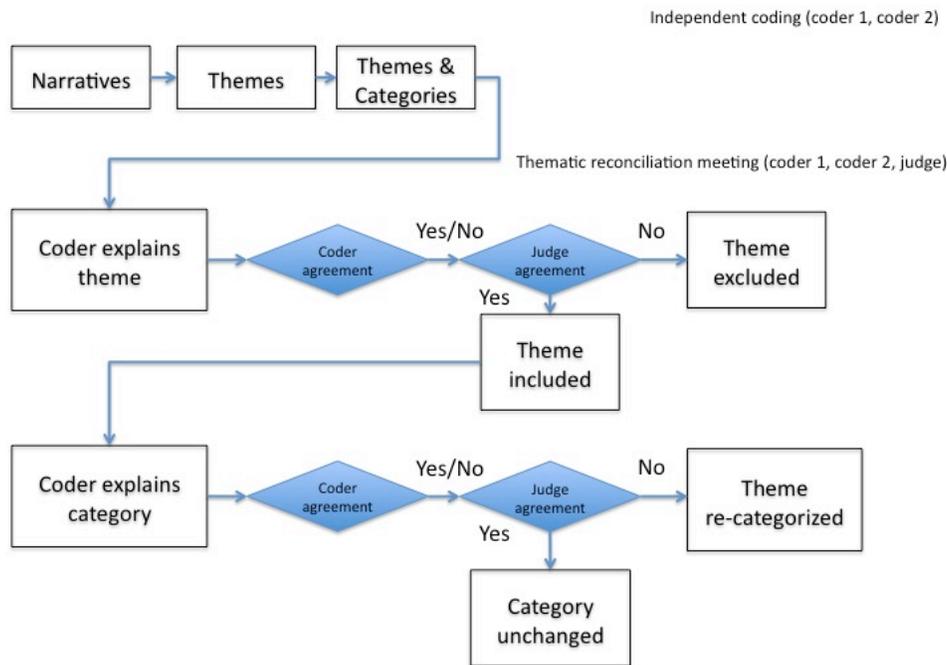


Figure 39. Process flow for thematic reconciliation meeting

Analysts participated in six face-to-face reconciliation meetings, which were scheduled for two hours each. Initial reconciliation meetings lasted the full two hours since new codes were frequently identified in earlier transcript codings as the code base was created. As the coding progressed, the code base increased and the likelihood of the identification of new codes decreased with later transcript codings. The data coding judge conducted the final two reconciliation meetings over email since not much reconciliation was required.

5.2.1.4.1 Preparation for reconciliation meetings

Coders uploaded archives of individual ATLAS.ti files to the online project site the day before scheduled reconciliation meetings.

The primary researcher downloaded the files, installed the archives, merged the analyses into one ATLAS.ti file, copied relative information from the automatically generated merge report into the reconciliation template (Appendix B.3), created an archive of the merged results, and uploaded the reconciliation template and archive to the project site.

The data coding judge downloaded the archive of the merged results and the reconciliation template. The judge installed the archive as a new ATLAS.ti file to be used during the reconciliation meeting.

5.2.1.4.2 Reconciliation meeting process

The data coding judge ran all reconciliation meetings. The data coding judge initiated discussion for all disagreements identified within the weekly reconciliation file. Two types of disagreements were discussed and reconciled during the weekly meetings: new codes and code categorizations. First, the judge initiated discussion regarding new codes identified by only one coder. The coder who identified the new code was prompted to explain the rationale behind the new code and to highlight quotations within the transcript(s) that supported the new code. The two coders then discussed the appropriateness of the new code and whether to keep or discard the code. When the coders were unable to agree, the data coding judge made the final decision and directed the conversation towards the next topic in the reconciliation file. Second, the judge initiated discussion regarding discrepancies in code categorizations. The judge prompted coders to explain the rationale behind the categorization and to highlight quotations within the transcript(s) that supported the categorizations. The two coders then discussed the appropriateness of the categorizations. Similar to new code discussions, the judge made final decisions when the coders were unable to reach an agreement.

The judge recorded all disagreements, agreements, and final decisions in the reconciliation file. After the reconciliation meeting, the judge used the reconciliation file to make all necessary changes to an updated version of the master ATLAS.ti file. The judge uploaded all reconciled ATLAS.ti files to the online project site, which the coders downloaded and used as the source for the next week's coding assignments.

5.2.1.4.3 Verification of user need set

The final results of the analyses (i.e., the final user needs set) were verified for correctness and completeness prior to further analyses of research questions. First, coders reviewed all transcripts to identify any missing codings. Since the code base was developed and expanded throughout the coding process, it was necessary to review all transcripts to ensure that new user needs identified in later transcripts weren't missed in transcripts coded before the user

need was discovered. Second, all user needs were reviewed to ensure that the specification adhered to the grammar rules. The primary researcher identified all user needs that did not adhere to the grammar. The primary researcher emailed the coders an Excel spreadsheet of the incorrectly specified user needs and a listing of the grammar rules. The coders rephrased the user needs according to the grammar and emailed a revised Excel worksheet to the primary investigator.

5.2.2 *Inter-coder reliability*

Inter-coder reliability for the thematic analysis team was established via training of coding procedures, which is described in Sections 5.3.4.1 and 5.3.4.2. In addition, the agreement calculation provides an additional measure of inter-coder agreement within the thematic analysis group. The procedure for determining the agreement calculation, which calculates the agreement per coding cycle in addition to the overall agreement, is described in Section 5.2.2.3.

5.2.2.1 Thematic analysis training

Analysts attended two 1-hour training sessions led by the primary researcher. In the first training session, analysts were provided with an overview of the research project and analysis approach via a PowerPoint presentation. Research questions were not discussed as not to bias coders. Analysts were also provided with an overview of ATLAS.ti features that would be used during analysis. The primary researcher demonstrated how to: a) access narrative files using the primary document manager, b) create codes and code data using the code manager, c) categorize codes using the family manager, and d) share files using the copy bundle feature.

In the second training session, the primary researcher presented the steps for thematic analysis of narratives (Appendix B.1). The analysts then coded the first four narratives within the GHH_P2P3 narrative transcript. This transcript was chosen to allow for practice analysis of both habitual and hypothetical narratives. This practice coding session accomplished three goals. First, it provided a low risk environment for analysts to practice the thematic analysis steps and use of the ATLAS.ti software with the ability to ask immediate questions. Second, it allowed the primary researcher the ability to provide real-time guidance when the analysts' coding differed from the "ideal" coding. The primary researcher created the ideal coding results during testing

and verification of the thematic analysis instructions. During the session, the primary researcher compared the analysts' coding results with the "ideal" coding results. When the coding results differed from the ideal set, the primary researcher would interject in the analysis discussion. For example, when a need was categorized into a different category than within the ideal set, the researcher would ask the analyst(s) to explain the rationale and to identify other possible categorizations with the group. When the analysts neglected to identify a need identified within the ideal set, the researcher would prompt analysts to re-visit a particular passage to look for additional needs. Finally, this training session allowed the primary researcher the ability to ascertain analysts' coding competency. Training was considered complete when analysts' coding matched 80% of the ideal set, which occurred at narrative 4.

5.2.2.2 Reconciliation meeting training

The primary researcher met with the data coding judge during one 30-minute training session. The primary researcher reviewed the reconciliation meeting instructions (Appendix B.2) and reconciliation template (Appendix B.3) and addressed the judge's questions regarding the process. The primary researcher also demonstrated ATLAS.ti functions that would be needed during reconciliation meetings, such as deleting, renaming, and merging codes in the code manager and changing code categorizations within the family manager. The judge practiced these functions using a test copy of the master ATLAS.ti file.

The primary researcher also attended the first reconciliation meeting to address any questions about the reconciliation process. The primary researcher did not provide any feedback regarding reconciliation decisions as not to bias analysts' decisions. The primary researcher also used this opportunity to observe the judge's competency in facilitating discussion and resolving disagreements to determine if additional training was required. The judge's skills were viewed as satisfactory so no additional training was required.

5.2.2.3 Percent Agreement

Thematic coders analyzed 2 transcripts per cycle, for a total of 22 transcripts coded over 11 coding cycles. ATLAS.ti tools facilitated calculation of the percent agreement for the entire thematic analysis data set for each coding cycle. For example, the generated merge report was

used to identify new codes created by each coder during each coding cycle. The code manager export function was used to identify unique codes used by each coder for each transcript. The percent agreement for each coding cycle **before reconciliation** was calculated as:

$$\text{Percent agreement} = \frac{\#CodesIncluded_{agreed} + \#CodesExcluded_{agreed}}{\#CodeList_{current} + \#NewCodes_{coder1} + \#NewCodes_{coder2}} \quad (1)$$

Inter-coder agreement ranged from 0.02 to 0.66 (Figure 41). The low agreement during the first cycle is expected, as a baseline code list was not yet created prior to this cycle. Since the thematic analysis followed a grounded theory approach, all identified user needs within Cycle 1 required the creation of new codes, which were then reconciled to form the current code list for Cycle 2. The percent agreement for subsequent cycles increased dramatically after Cycle 1, ranging from 0.54 to 0.66.

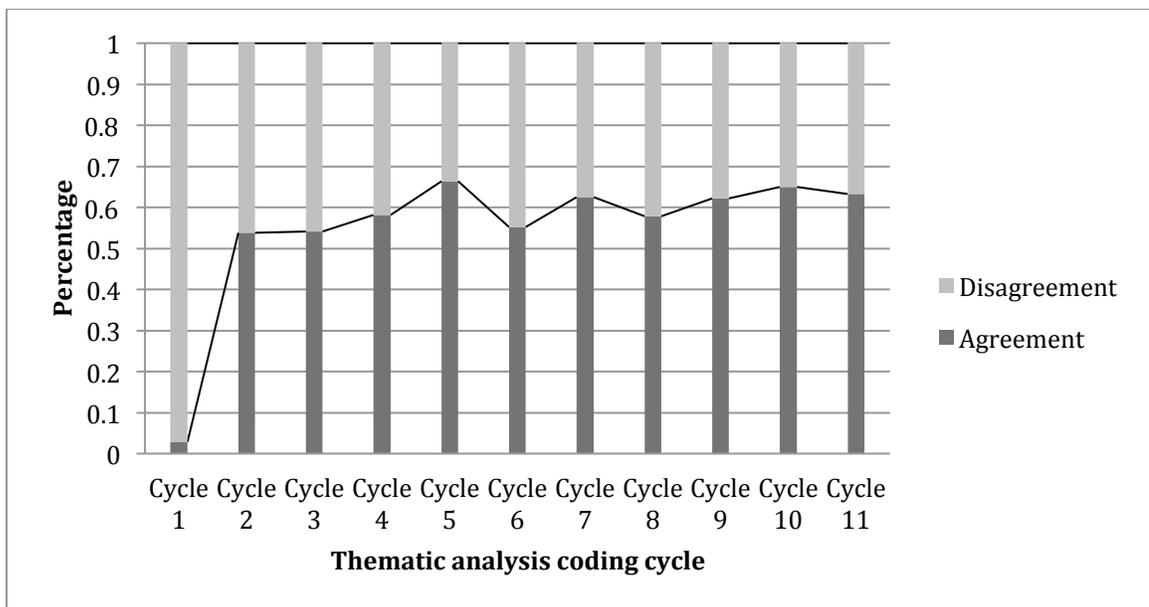


Figure 40. Percent agreement for each thematic analysis coding cycle

No judge decisions were required during the reconciliation meetings as the two coders were able to reach mutual agreements. As a result, the reported inter-coder reliability after the reconciliation meeting for each coding cycle was 1.0

5.2.3 RQ1 Analyses

The purpose of RQ1 (i.e., “What is the impact of the framework’s elicitation methods on design?”) was to determine if participants focused on different user needs as a result of the differences in storytelling context. In this study, storytelling context was defined by session setting (i.e., individual, group) and question prompts (i.e., habitual & hypothetical, habitual).

Similar to previous work (Gausepohl, 2008), we analyzed elicited user needs for robustness. We operationally defined robustness as the quantity and quality of the elicited user needs. Quantity was defined as the number of distinct user needs contributed per participant. Quality was interpreted by the breadth and depth of the compiled user need sets. RQ1a-1 addressed the quantity of user needs. RQ1a-2 and RQ1a-3 addressed user needs quality in terms of breadth and depth of the compiled need sets. The following sections detail the analyses for RQ1a-1 through RQ1a-3.

5.2.3.1 RQ1a: What is the impact of storytelling context (i.e., setting, questions) on the user needs elicited?

5.2.3.1.1 RQ1a-1: What is the impact of storytelling context on the *quantity* of user needs elicited?

The purpose RQ1a-1 was to determine if participants focused on different usability categories as a result of the differences in session context (i.e., setting, questions). To allow for comparisons between treatments, all group participants were considered to own all user needs resulting from the group storytelling session since the session was a group effort. Table 17 provides a summary of the RQ1a-1 hypotheses explored in this work.

Table 17. Hypotheses for RQ1a-1 - quantity of user needs

| RQ1a-1 | Independent variable | Hypotheses |
|---------------|-----------------------------|---|
| -1a | setting | Group storytelling sessions will elicit more usability needs than individual sessions. |
| -2a | questions | Habitual and hypothetical prompts will elicit more usability needs than habitual prompts. |
| -3a | setting*questions | Group sessions with habitual and hypothetical prompts will elicit the most usability needs. |

Since completion of Phase 1 (i.e., Elicitation of ER nurses’ Stories) was required in support of RQ1, Section 4.1.1 in the previous chapter provides an overview of the research design, a listing of the predictor and response variables investigated in Phase 1 and Phase 2, as well as the statistical analyses approach for RQ1. Section 4.1.1.1 also summarizes how regression models were selected and the approach for testing of group differences.

5.2.3.2 RQ1a-2: What is the impact of storytelling context on the *breadth* of the compiled set?

In addition to user need quantity, the quality of the collected user need sets was also explored. The purpose of RQ1a-2 was to investigate if participants discussed a broader range of themes as a result of the differences in treatments. Breadth was considered to be a factor of a ‘better’ set of requirements since it indicates the group’s coverage of all possible requirements categories. In this respect, greater breadth is directly proportional to greater quality. Breadth per person was calculated as:

$$\text{Breadth} = \frac{\# \text{ categories discussed}}{\text{total \# categories}} = \frac{\# \text{ categories discussed}}{12} \quad (2)$$

No expected difference in the breadth between groups was expected prior to analyses (Table 18).

Table 18. Hypotheses for RQ1a-2 - breadth of categories discussed

| RQ1a-2 | Independent variable | Hypotheses |
|---------------|-----------------------------|-------------------------|
| -1a | setting | No expected difference. |
| -2a | questions | No expected difference. |
| -3a | setting*questions | No expected difference. |

A two-way ANOVA for fixed effects was used to test for interactions and factor effects in the breadth of categories discussed. An alpha level of 0.05 was used to determine which interactions and main effects to include in the generalized linear model used for subsequent tests between groups.

5.2.3.3 RQ1a-3: What is the impact of storytelling context on the *depth* of the compiled set?

The purpose of RQ1a-3 was to investigate differences in the depth (i.e., quantity of needs within each category) of compiled results. The compiled results for each group was of interest because the value of a set of user needs is ultimately judged by the set of responses and not by the individual responses. For example, if a requirements engineer interviews 5 people who all express the same 20 user needs, the requirements engineer has only identified 20 user needs across all 5 participants. However, if the 5 people revealed 20 distinct user needs each, the requirements engineer has collected 100 (5x20) distinct user needs.

Since individual sessions (n = 8) had more participants than group sessions (n = 6), 2 participants were randomly removed from both individual groups (i.e., IH, IHH) to allow for comparisons between groups. The random number generator in MS Excel was used to determine which participants to remove from each individual session group. Participants P4 and P10 were removed from the IHH set and participants P13 and P23 were removed from the IH set. The total number of needs identified per group was calculated as the union of all sessions within the chosen grouping (Figure 41).

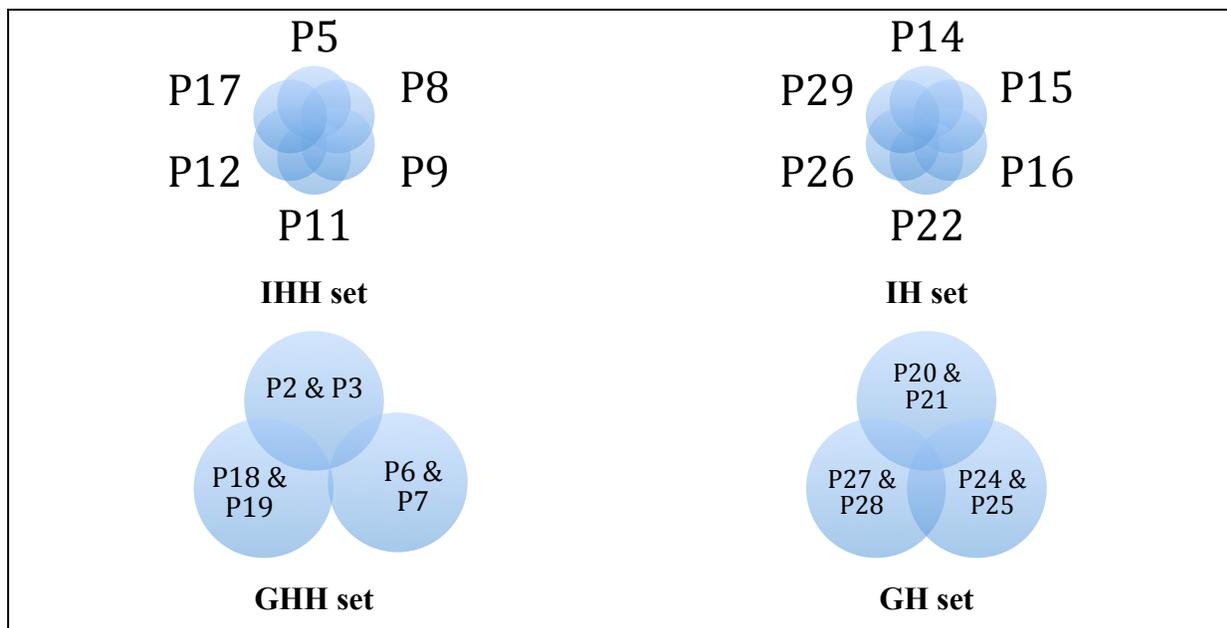


Figure 41. Example compiled user needs for depth comparisons

For example, the total usability needs for the IHH set was calculated as:

$$\begin{aligned}
\text{Total_Usability_Themes}_{\text{IHH}} = & \\
& \text{Total_Usability_Themes_IHH}_{\text{P5}} \cup \\
& \text{Total_Usability_Themes_IHH}_{\text{P8}} \cup \\
& \text{Total_Usability_Themes_IHH}_{\text{P9}} \cup \\
& \text{Total_Usability_Themes_IHH}_{\text{P11}} \cup \\
& \text{Total_Usability_Themes_IHH}_{\text{P12}} \cup \\
& \text{Total_Usability_Themes_IHH}_{\text{P17}}
\end{aligned}$$

For the hypotheses below, any discrepancy greater than or equal to 10% was considered to demonstrate potential support for the hypothesis. Since this study was exploratory in nature a 10% increase was considered to be a significant increase (Gausepohl et al., 2011). However, any hypothesis with less than 30 data points was considered to be inconclusive. The cutoff was set at 30 data points to account for a minimum average of 5 identified themes per participant (5 themes x 6 participants per group). Hygienic and physical categories were excluded from analyses as these categories only contained 8 and 2 user needs each, respectively. All other categories were included in the analyses.

Hypotheses for the impact of setting, questions, and the setting*questions interaction were developed prior to analysis in an effort to explore RQ1a-3 (Table 17). The following hypotheses were developed prior to analysis to explore the impact of setting on the depth of compiled need sets (Table 19).

Table 19. Hypotheses for RQ1a-3 - impact of session setting on depth of compiled user needs

| RQ1a-3 | Needs | Hypotheses for Setting Factor |
|---------------|---------------|---|
| -1a | total | Group storytelling participants (G) will collectively identify more distinct total needs than individual participants (I). |
| -1b | functional | Group storytelling participants (G) will collectively identify more distinct functional needs than individual participants (I). |
| -1c | usability | Group storytelling participants (G) will collectively identify more distinct usability needs than individual participants (I). |
| -1d | effectiveness | No expected difference. |
| -1e | efficiency | No expected difference. |
| -1f | satisfaction | Group storytelling participants (G) will collectively identify more distinct satisfaction needs than individual participants (I). |
| -1g | context | Group storytelling participants (G) will collectively identify more distinct context-of-use needs than individual participants (I). |
| -1h | activity | Group storytelling participants (G) will collectively identify more distinct activity needs than individual participants (I). |
| -1i | hygienic | No expected difference. |
| -1j | physical | No expected difference. |
| -1k | social | Group storytelling participants (G) will collectively identify more distinct social themes than individual participants (I). |
| -1l | spatial | No expected difference. |
| -1m | technological | No expected difference. |

The following hypotheses were developed prior to analysis to explore the impact of question type on the depth of compiled needs sets (Table 20).

Table 20. Hypotheses for RQ1a-3 - impact of question type on depth of compiled user needs

| RQ1a-3 | Needs | Hypotheses for Question Factor |
|--------|---------------|--|
| -2a | total | HH participants will collectively identify more distinct total needs than H participants |
| -2b | functional | HH participants will collectively identify more distinct functional needs than H participants |
| -2c | usability | HH participants will collectively identify more distinct usability needs than H participants |
| -2d | effectiveness | No expected difference. |
| -2e | efficiency | No expected difference. |
| -2f | satisfaction | HH participants will collectively identify more distinct satisfaction needs than H participants |
| -2g | context | HH participants will collectively identify more distinct context needs than H participants |
| -2h | activity | HH participants will collectively identify more distinct activity needs than H participants |
| -2i | hygienic | No expected difference. |
| -2j | physical | No expected difference. |
| -2k | social | HH participants will collectively identify more distinct social needs than H participants |
| -2l | spatial | No expected difference. |
| -2m | technological | No expected difference. |

The following hypotheses were developed prior to analyses to explore the impact of the setting*question interaction on the depth of compiled user needs.

Table 21. Hypotheses for the impact of the setting*question interaction on depth of compiled user needs

| RQ1a-3 | Needs | Hypotheses |
|---------------|---------------|---|
| -3a | total | GHH participants will collectively identify more total user needs than IHH, IH and GH participants. The compiled IHH and GH sets will contain more total needs than the IH set. |
| -3b | functional | GHH participants will collectively identify more functional needs than IHH, IH and GH participants. The compiled IHH and GH sets will contain more total needs than the IH set. |
| -3c | usability | GHH participants will collectively identify more usability needs than IHH, IH and GH participants. |
| -3d | effectiveness | No expected difference. |
| -3e | efficiency | No expected difference. |
| -3f | satisfaction | GHH participants will collectively identify more satisfaction needs than IHH, IH and GH participants. The compiled IHH and GH sets will contain more satisfaction needs than the IH set. |
| -3g | context | GHH participants will collectively identify more context needs than IHH, IH and GH participants. The compiled IHH and GH sets will contain more context needs than the IH set. |
| -3h | activity | GHH participants will collectively identify more activity needs than IHH, IH and GH participants. The compiled IHH and GH sets will contain more activity needs than the IH set. |
| -3i | hygienic | No expected difference. |
| -3j | physical | No expected difference. |
| -3k | social | GHH participants will collectively identify more social needs than IHH, IH and GH participants. The compiled IHH and GH sets will contain more social needs than the IH set. |
| -3l | spatial | No expected difference. |
| -3m | technological | No expected difference. |

5.3 Results

Thematic analysis of participant narratives resulted in the identification of 383 distinct user needs (Figure 42). Of these user needs, 130 were categorized as functional needs and 301 were categorized as usability needs. Forty-seven needs were categorized as both functional and usability needs as the analysis instructions allowed for overlap between user need categories. For example, the user need “use internet” was categorized as a functional need since it described *what* needed to be done. However, as the need also describes the technological context of the activity, it was also categorized within the technological context, context, and usability categories.

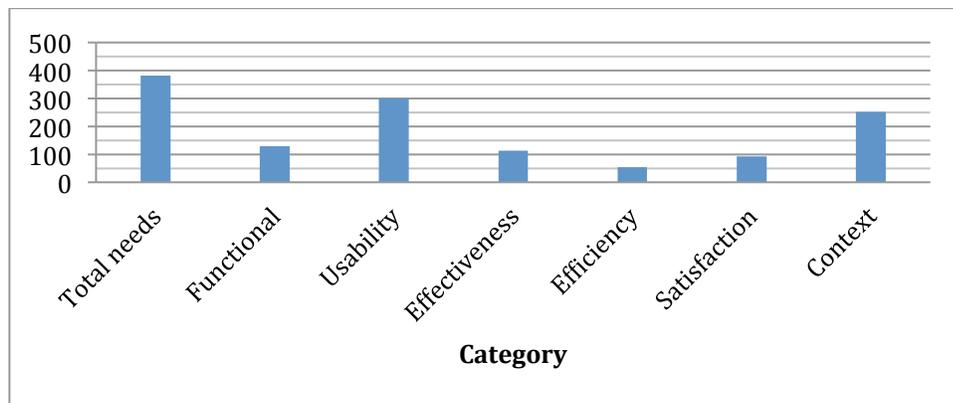


Figure 42. Total functional and usability needs collected as a result of this work

A total of 301 distinct usability needs were identified (Figure 43). Of these usability needs, 114 were categorized as effectiveness, 53 were categorized as efficiency, 93 were categorized as satisfaction, and 252 were categorized as context needs.

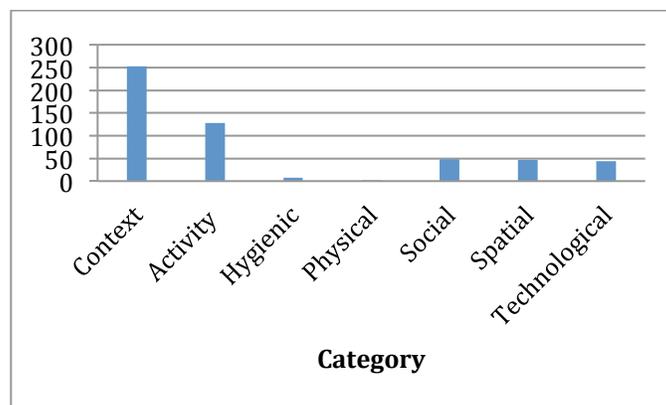


Figure 43. Total contextual needs collected as a result of this work

Of the 221 context needs, the majority were categorized as activity context (n=128). Social context, spatial context, and technological context categorizes were comprised of 48, 47, and 44 total needs, respectively. Only 8 hygienic and 2 physical context were identified.

A full listing of identified user needs is available in Appendix B.5.

5.3.1 RQ1: *What is the impact of the framework's elicitation methods on design?*

Our investigation of the overall research question “How does the Design + Storytelling framework impact design?” was supported by RQ1, which explored the impact of the different elicitation methods on design. Specifically, we investigated the impact of the elicitation methods on the user needs elicited (i.e., RQ1a) in terms of quantity (i.e., RQ1a-1), breadth (i.e., RQ1a-2), and depth (i.e., RQ1a-3).

5.3.1.1 RQ1a: What is the impact of storytelling context (i.e., setting, questions) on the user needs elicited?

Section 5.3.1.2 through Section 5.3.1.4 detail the results for RQ1.

5.3.1.2 RQ1a-1: What is the impact of storytelling context on the quantity of user needs elicited?

A summary of the significant interaction and main effects resulting from a three factor ANOVA (i.e., setting, questions, duration) is provided in Table 22. Section 5.3.1.2.1 through Section 5.3.1.2.13 detail the results for each category of user needs.

Table 22. RQ1a-1: Three factor ANOVA for main and interaction effects

| | Setting (S) | Questions (Q) | Duration (D) | S x Q | Q x D | S x D | S x Q x D |
|----------------|--------------------------|----------------------|--------------------------|-----------------|------------------|--------------------------|------------------|
| Needs | <i>F</i> (1,10) | <i>F</i> (1, 10) | <i>F</i> (2, 10) | <i>F</i> (2,10) | <i>F</i> (2, 10) | <i>F</i> (2, 10) | <i>F</i> (2, 10) |
| | <i>p</i> | <i>p</i> | <i>p</i> | <i>p</i> | <i>p</i> | <i>p</i> | <i>p</i> |
| Total | 42.93 < .0001** | 0.61 .45 | 16.80 .0006* | 0.53 .48 | 0.47 .64 | 6.78 .01* | 2.07 .17 |
| Functional | 17.94 .0017* | 0.47 .51 | 7.29 .01* | 0.0 .96 | 0.38 .69 | 2.36 .15 | 0.36 .71 |
| Usability | 30.62 .0002* | 0.32 .58 | 16.09 .0007* | 0.33 .58 | 0.62 .56 | 4.88 .03* | 1.61 .24 |
| Effectiveness | 10.79 .008* | 0.84 0.38 | 9.75 .005* | 0.09 .77 | 0.37 0.69 | 1.97 0.19 | 1.45 .28 |
| Efficiency | 5.14 .05 ⁺ | 2.27 .16 | 6.02 .02* | 0.32 .58 | 1.46 .28 | 0.09 .91 | 0.12 .89 |
| Satisfaction | 13.90 .004* | .05 .83 | 4.03 .05 ⁺ | 0.33 .58 | 0.25 .78 | 1.81 .21 | 0.39 .69 |
| Context-of-use | 27.87 .0004* | 0.0 .96 | 12.84 .0017* | 0.39 .55 | .31 .74 | 4.23 .05 ⁺ | 1.28 .32 |
| Activity | 17.61 .0018* | 7.21 .03* | 12.8 .002* | .01 .92 | 1.41 .29 | 2.32 .15 | .49 .63 |
| Hygienic | 0.0 .98 | 0.0 .98 | 0.08 .93 | 0.0 .97 | 0.19 .83 | 0.33 .73 | .02 .98 |
| Physical | 0.0 1.0 | 0.0 1.0 | 0.0 1.0 | 0.0 1.0 | 0.0 1.0 | 0.0 1.0 | 0.0 1.0 |
| Social | 4.72 .06 ⁺ | .03 .86 | 1.64 .24 | 0.04 .85 | 0.50 .62 | 0.21 .82 | 0.13 .88 |
| Spatial | 2.59 .14 | 1.63 .23 | 2.13 .17 | 0.0 .95 | 0.08 .92 | 3.70 .06 | 0.29 .75 |
| Technological | 5.37 .04* | 0.0 .96 | 3.56 .07 ⁺ | 0.01 .93 | 0.47 .64 | 0.92 .43 | 1.07 .38 |

*p<.05, ** p <.0001, + approached significance

5.3.1.2.1 Total needs

The interaction between setting and time was found to be significant, $F(1, 10) = 6.78, p = .01$; the main effects were also included in the model for post-hoc analyses. Participants in group sessions of average duration ($M = 137.8, SD = (-8.3, 8.8)$) contributed more user needs than participants in individual sessions of average duration ($M = 93, SD = (-3.4, 3.5)$), $t(16) = 6.82, p < .0001$ (Figure 44). Participants in group sessions of short duration ($M = 116, SD = (-7.4, 7.9)$) contributed more user needs than participants in individual sessions of short duration ($M = 86.3, SD = (-4.5, 4.8)$), $t(16) = 3.49, p = .03$.

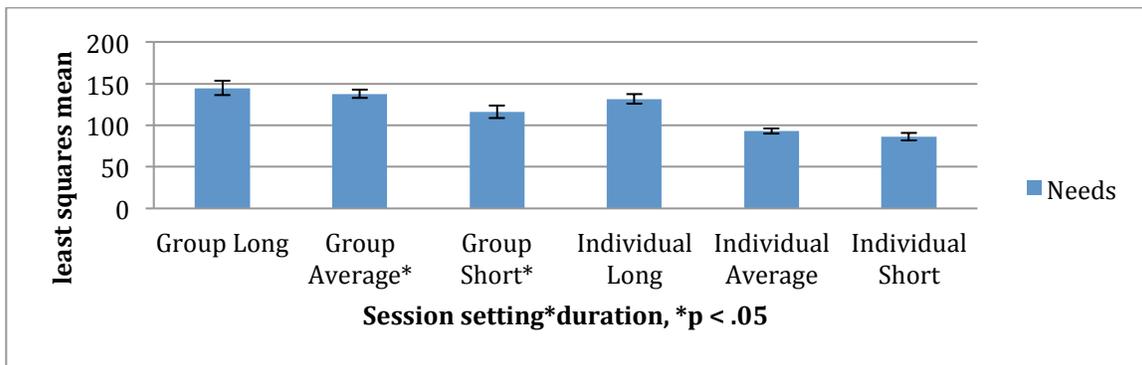


Figure 44. User need difference by session*duration

5.3.1.2.2 Functional needs

Setting and time were identified as significant main effects, $F(1, 10) = 17.94, p = .0017$ and $F(2, 10) = 7.29, p = .01$, respectively.

Participants in group storytelling sessions ($M = 45.9, SD = (-2.7, 2.8)$) contributed more functional needs than participants in individual sessions ($M = 33.3, SD = (-1.5, 1.5)$), $t(18) = 4.31, p = .0004$ (Figure 45).

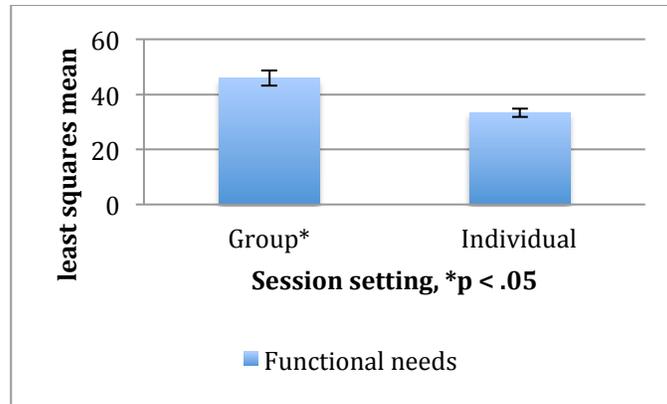


Figure 45. Functional needs differences by session setting

Participants in long duration sessions ($M = 48.3$, $SD = (-2.8, 3.0)$) contributed more user needs than those in average duration ($M = 38$, $SD = (-2.1, 2.2)$) or short duration sessions ($M = 32.9$, $SD = (-2.3, 2.5)$), $t(18) = 3.09$, $p = .02$ and $t(18) = 4.09$, $p = .002$, respectively (Figure 46).

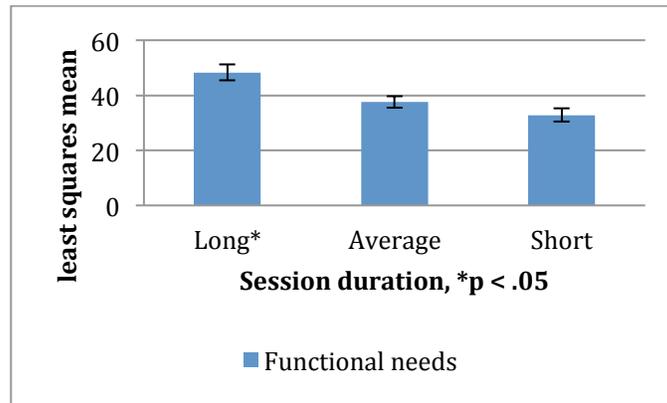


Figure 46. Functional needs differences by session duration

5.3.1.2.3 Usability needs

The interaction between setting and time was found to be significant, $F(2, 10) = 4.88$, $p = .03$; the main effects were also included in the model during post-hoc analyses.

Participants in group sessions of average duration ($M = 117.0$, $SD = (-7.4, 7.9)$) contributed more usability needs than participants in individual sessions of average duration ($M = 75.5$, $SD = (-3.0, 3.1)$), $t(16) = 5.69$, $p = .0004$ (Figure 47).

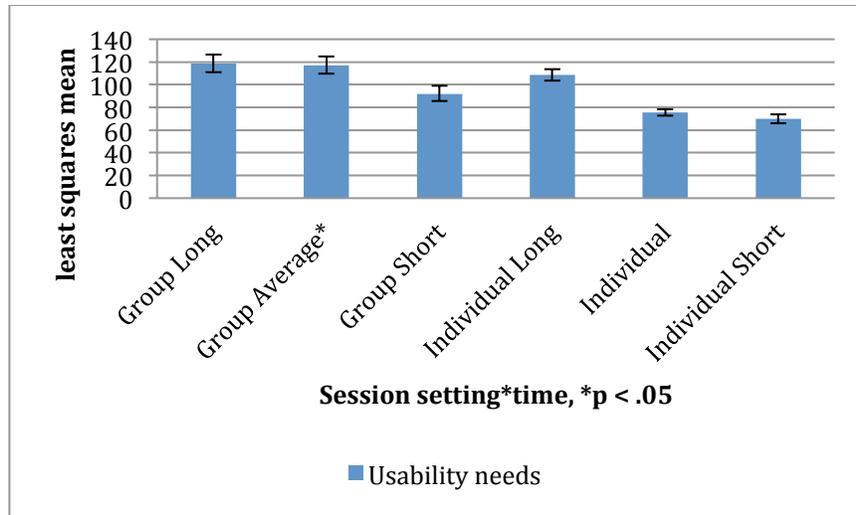


Figure 47. Usability needs differences by setting*time

5.3.1.2.4 Effectiveness needs

Setting and time were identified as significant main effects, $F(1, 10) = 10.79, p = .008$ and $F(2, 10) = 9.75, p = .005$, respectively.

Participants in group storytelling sessions ($M = 40.8, SD = (-2.5, 2.7)$) contributed more effectiveness needs than participants in individual sessions ($M = 31.0, SD = (-1.4, 1.5)$), $t(18) = 3.49, p = .003$ (Figure 48).

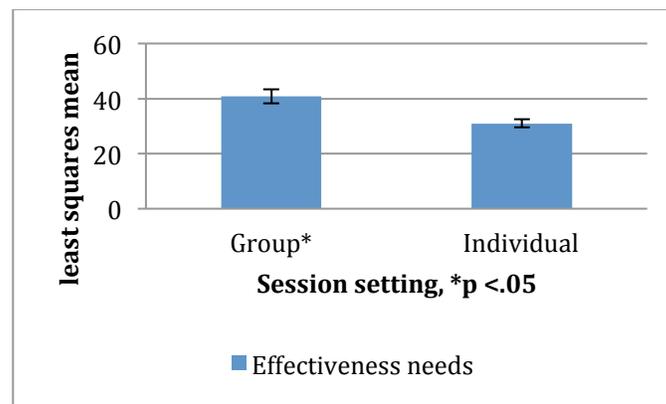


Figure 48. Effectiveness needs differences by session setting

Participants in long duration sessions ($M = 44.8, SD = (-2.7, 2.9)$) contributed more effectiveness needs than those in average duration sessions ($M = 35.6, SD = (-2.0, 2.2)$) and short duration sessions ($M = 28.2, SD = (-2.1, 2.3)$), $t(18) = 2.74, p = .03$, and $t(18) = 4.63, p = .0006$, respectively (Figure 49).

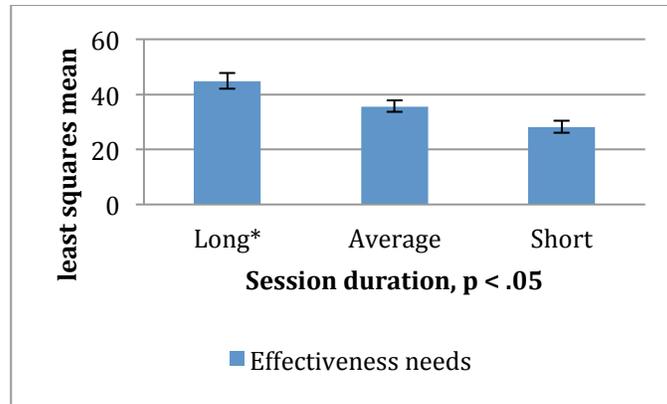


Figure 49. Effectiveness needs differences by session duration

5.3.1.2.5 Efficiency needs

Duration was identified as a significant main effect, $F(2, 10) = 6.02, p = .02$. Session setting approached significance, $F(1,10) = 5.14, p = .05$.

Participants in long duration sessions ($M = 19.0, SD = (-1.8, 2.0)$) contributed more efficiency needs than those in short duration sessions ($M = 11.3, SD = (-1.4, 1.5)$), $t(19) = 3.37, p = .009$ (Figure 50).

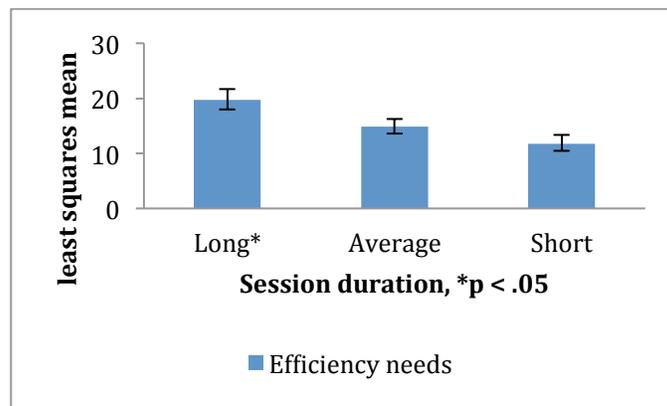


Figure 50. Efficiency needs differences by session duration

5.3.1.2.6 Satisfaction needs

Setting was identified as a main effect, $F(1, 10) = 13.9, p = .004$. Session duration approached significance, $F(2,10) = 4.03, p = .05$. The interaction was not found to be significant.

Group sessions ($M = 39.2, SD = (-2.5, 2.6)$) elicited more satisfaction needs than individual sessions ($M = 28.5, SD = (-1.4, 1.4)$), $t(20) = 3.93, p = .0008$ (Figure 51).

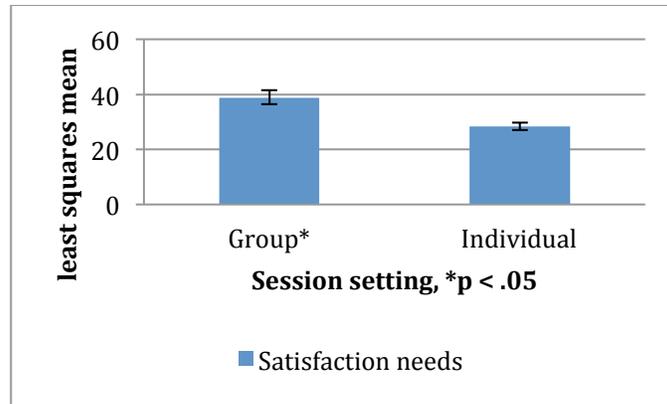


Figure 51. Satisfaction needs differences by session setting

5.3.1.2.7 Context

Setting and duration were identified as significant main effects, $F(1, 10) = 27.87, p = .0004$ and $F(2, 10) = 12.84, p = .0017$, respectively.

The interaction between setting and duration approached significance, $F(2, 10) = 4.3, p = .03$.

Participants in group storytelling sessions ($M = 84.1, SD = (-3.7, 3.9)$) contributed more context needs than participants in individual sessions ($M = 62.7, SD = (-2.1, 2.1)$), $t(18) = 5.35, p < .0001$ (Figure 52).

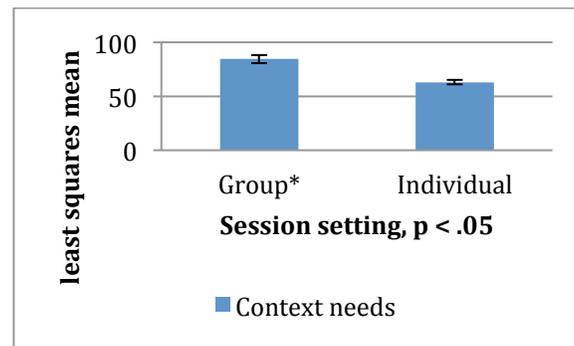


Figure 52. Context needs differences by session setting

Participants in long duration sessions ($M = 89.6, SD = (-3.9, 4.1)$) contributed more context needs than those in average duration ($M = 69.4, SD = (-3.1, 3.2)$) and short duration sessions ($M = 61.5, SD = (-3.3, 3.4)$), $t(18) = 4.20, p = .0012$ and $t(18) = 5.45, p < .0001$, respectively (Figure 53).

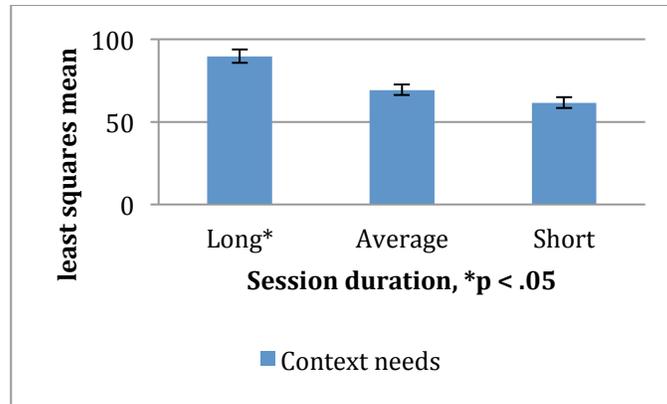


Figure 53. Context needs differences by session duration

5.3.1.2.8 Activity context

Setting, question type and time were identified as main effects, $F(1, 10) = 17.61, p = .0018$, $F(1, 10) = 7.21, p = .03$, and $F(2, 10) = 12.8, p = .002$, respectively.

Group sessions ($M = 36.1, SD = (-2.4, 2.5)$) elicited more activity context needs than individual sessions ($M = 25.1, SD = (-1.3, 1.3)$), $t(17) = 4.29, p = .0005$ (Figure 54).

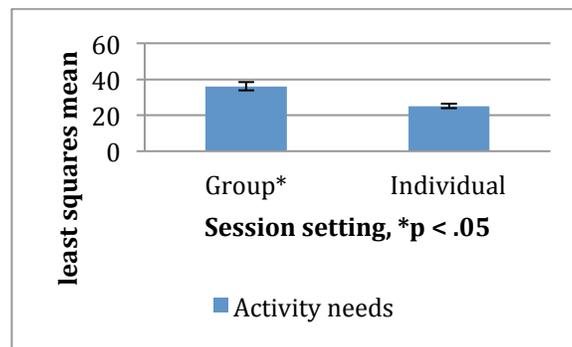


Figure 54. Activity needs differences by session setting

Habitual sessions ($M = 33.1, SD = (-1.8, 1.9)$) elicited more activity context needs than sessions with both habitual and hypothetical questions ($M = 27.4, SD = (-1.6, 1.7)$), $t(17) = 2.36, p = .03$ (Figure 55).

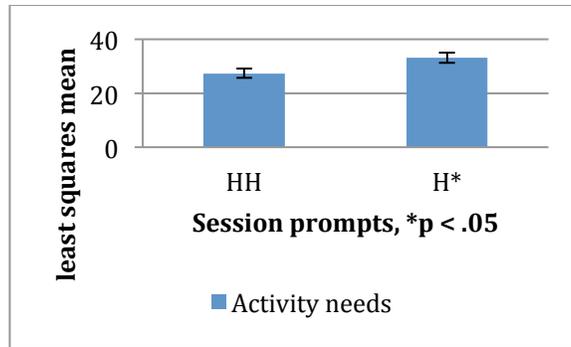


Figure 55. Activity need differences by session prompts

Long duration sessions ($M = 41.0$, $SD = (-2.6, 2.8)$) elicited more activity context needs than average duration ($M = 26.8$, $SD = (-1.7, 1.9)$) and short duration sessions ($M = 24.8$, $SD = (-2.0, 2.2)$), $t(17) = 4.61$, $p = .0007$ and $t(17) = 4.73$, $p = .0005$, respectively (Figure 56).

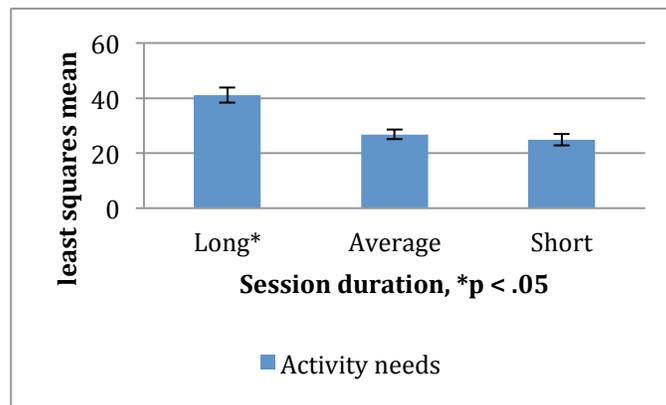


Figure 56. Activity needs differences by session duration

5.3.1.2.9 Hygienic context

No main effects or interaction effects were found.

5.3.1.2.10 Physical context

No main effects or interaction effects were found.

5.3.1.2.11 Social context

Setting approached significance, $F(1, 10) = 4.72$, $p = .06$.

5.3.1.2.12 Spatial context

An interaction effect for setting and duration approached significance, $F(2, 10) = 3.70, p = .06$.

5.3.1.2.13 Technological context

Setting was identified as a main effect, $F(1,10) = 5.37, p = .04$, and a main effect for duration approached significance, $F(2,10) = 3.56, p = .07$.

Group sessions ($M = 13.5, SD = (-1.4, 1.6)$) elicited more technological context needs than individual sessions ($M = 9.5, SD = (-0.8, 0.8)$), $t(20) = 2.55, p = 0.02$ (Figure 57).

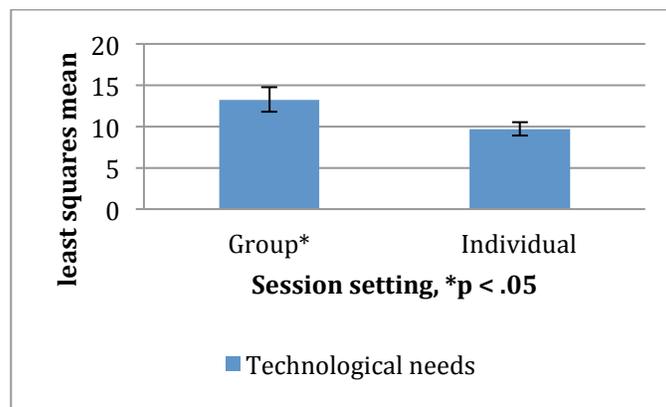


Figure 57. Technological needs differences by session setting

5.3.1.2.14 Summary of findings – RQ1a-1

Table 23 Summary of findings for RQ1a-1.

| RQ1a-1 | Hypotheses | Finding |
|---------------|----------------------|---|
| -1a | Not Supported | Participants in group (G) sessions contributed a greater quantity of needs than participants in individual (I) sessions for all categories except for hygienic and physical context. |
| -2a | Not Supported | Participants prompted by habitual (H) questions contributed more activity context needs than participants prompted by habitual & hypothetical (HH) questions. |
| -3a | Supported | The setting*question interaction was insignificant for all user need categories. No significant differences in the quantity of user needs between GHH, GH, IHH, or IH participants were found. |

5.3.1.3 RQ1a-2: What is the impact of storytelling context on the *breadth* of the compiled set?

In terms of compiled requirements, all groups covered all 13 categories, resulting in a perfect 1.0 breadth score.

Additional post-hoc analyses on the breadth of user needs contributed per person were conducted. On average, participants mentioned user needs for 12 of the 13 categories (min=11, max=13).

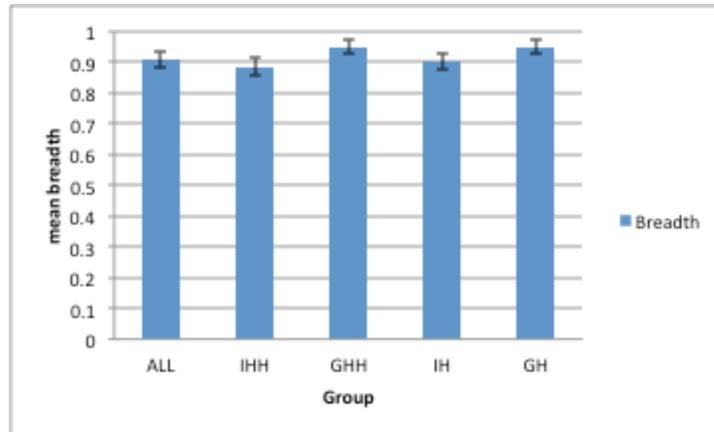


Figure 58. Mean breadth per group

No main effects or interaction effects were found (Table 23).

Table 24. Three factor ANOVA for breadth per person

| | Setting (S) | Questions (Q) | Duration (D) | S x Q | Q x D | S x D | S x Q x D |
|----------------|-------------|---------------|--------------|-----------|-----------|-----------|-----------|
| | $F(1,10)$ | $F(1,10)$ | $F(2,10)$ | $F(1,10)$ | $F(2,10)$ | $F(2,10)$ | $F(2,10)$ |
| | p | p | p | p | p | p | p |
| Breadth | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | .96 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |

Additional testing for other factor effects (i.e., age, facility, experience, gender, quantity of narratives) did not result in the identification of any factor effects or interactions.

5.3.1.3.1 Summary of findings RQ1a-2

Table 25. Summary of findings for the impact of setting, questions, and setting*questions on breadth of user need sets

| RQ1a-2 | Hypotheses | Finding |
|--------|------------|--|
| -1a | Supported | Setting was not a factor effect for breadth. No significant differences were found in the breadth of categories discussed by participants in group (G) sessions or individual (I) sessions. |
| -2a | Supported | Question type was not a factor effect for breadth. No significant differences were found in the breadth of categories discussed by participants prompted by habitual (H) questions or participants prompted by habitual & hypothetical (HH) questions. |
| -3a | Supported | The setting*question interaction was insignificant for breadth. No significant differences in the breadth of categories discussed by GHH, GH, IHH, or IH participants were found |

5.3.1.4 RQ1a-3: What is the impact of storytelling context on the *depth* of the compiled set?

In addition to breadth, the depth (i.e., quantity of user needs within each category) was investigated as an additional quality measure of each user need set. Section 5.3.1.4.1 provides an overview of the methods used within each compiled set used during the investigation of RQ1a-3.

5.3.1.4.1 Methods used within each compiled set

Table 26 and Table 27 provide an overview of the methods used within each compiled set. As shown in Table 26, the IHH, GHH, IH, and GH compiled sets were used during investigations of the impact of the setting*questions interaction on depth.

Table 26. Compiled sets used to investigate impact of the setting*questions interaction on depth

| Compiled Set | Setting | Questions | Sessions (min = 3, max = 6) | Participants <i>N</i> = 6 |
|--------------|------------|-------------------------|--------------------------------|------------------------------|
| IHH | Individual | Habitual & hypothetical | <i>N</i> = 6 | <i>N</i> = 6 |
| GHH | Group | Habitual & hypothetical | <i>N</i> = 3 | <i>N</i> = 6 |
| IH | Individual | Habitual | <i>N</i> = 6 | <i>N</i> = 6 |
| GH | Group | Habitual | <i>N</i> = 3 | <i>N</i> = 6 |

As shown in Table 27, additional sets were created to investigate the impact of setting and questions on the depth of compiled user need sets. For example, the G set was comprised of all user needs identified via GHH and GH sessions. In contrast to the sets detailed in Table 26, which represented user needs collected from 6 participants, these sets were the result of stories collected from 12 participants.

Table 27. Compiled sets used to investigate impact of setting and questions on depth

| Compiled Set | Methods | Sessions (min = 6, max = 12) | Participants <i>N</i> = 12 |
|--------------|---------|---------------------------------|-------------------------------|
| G | GHH | (n = 3) | (n = 6) |
| | GH | (n = 3) | (n = 6) |
| | | <i>N</i> = 6 | <i>N</i> = 12 |
| I | IHH | (n = 6) | (n = 6) |
| | IH | (n = 6) | (n = 6) |
| | | <i>N</i> = 12 | <i>N</i> = 12 |
| HH | IHH | (n = 6) | (n = 6) |
| | GHH | (n = 3) | (n = 6) |
| | | <i>N</i> = 9 | <i>N</i> = 12 |
| H | IH | (n = 6) | (n = 6) |
| | GH | (n = 3) | (n = 6) |
| | | <i>N</i> = 9 | <i>N</i> = 12 |

5.3.1.4.2 Descriptive statistics for compiled groups

Descriptive statistics for the compiled groups are presented separately based on the number of participants within each group. Comparisons between the group (G), individual (I), habitual (H) and habitual & hypothetical (HH) set of user needs are presented first. The compiled user needs for these groups were collected from 12 participants within each group. The compiled sets for the IHH, IH, GHH, and GH groups were created from the contributions of 6 participants each.

The compiled sets for habitual & hypothetical (HH) and group (G) sessions contained the most distinct user needs, with 325 and 323 user needs, respectively (Figure 59).

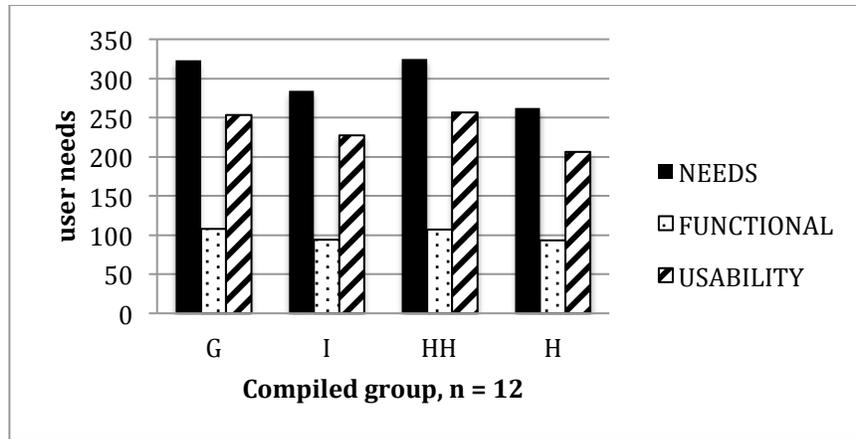


Figure 59. Distinct functional, usability and user needs for G, I, HH, and H groups

The compiled set for IH sessions contained the least amount of user needs among all groups (Figure 60). The IH set only contained 212 user needs. See Section 5.4.4.1.1 for a detailed analysis comparing the depth of functional needs across all groups.

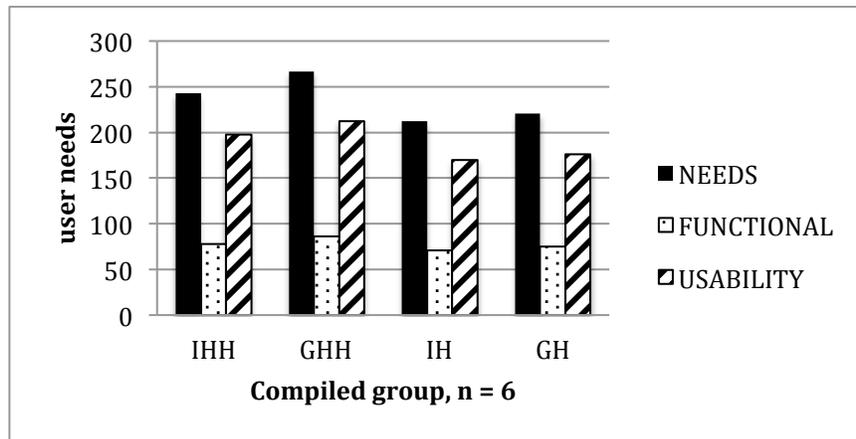


Figure 60. Distinct functional, usability and total needs for IHH, GHH, IH, and GH groups

The compiled sets for G and HH sessions were also superior in terms of usability and contextual needs, in comparison with other groups (Figure 61).

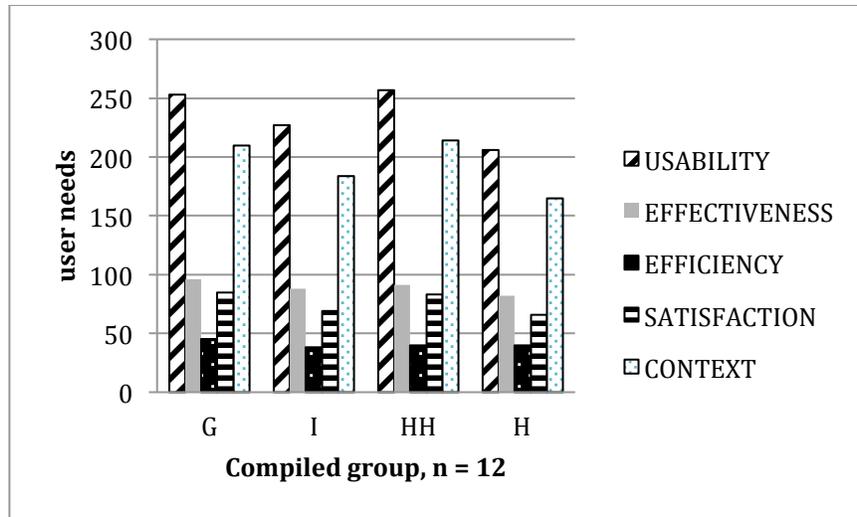


Figure 61. Distinct usability needs for G, I, HH, and H groups

The compiled HH set consisted of 257 distinct usability needs and the compiled G set consisted of 253 user needs (Figure 62). See Section 5.4.3.1.2 for a detailed analysis comparing the depth of usability needs across all groups.

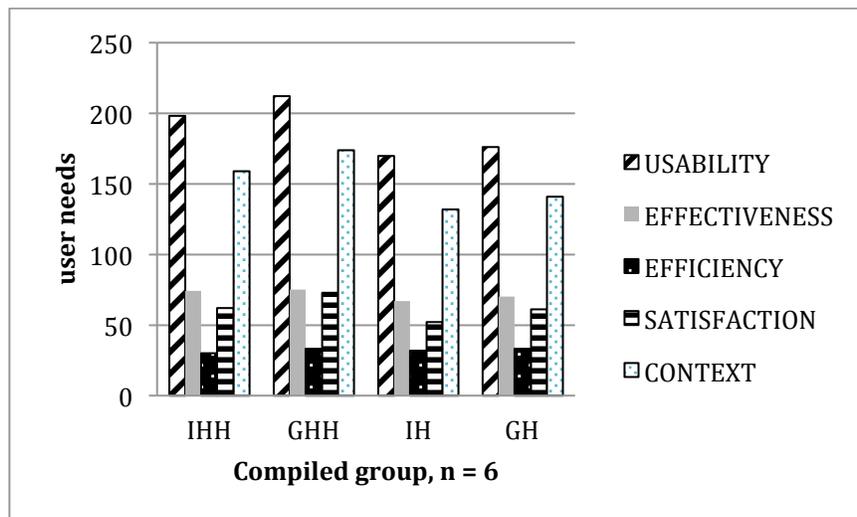


Figure 62. Distinct usability needs for IHH, GHH, IH, and GH groups

The G set also contained the most activity needs in comparison with other groups (Figure 63).

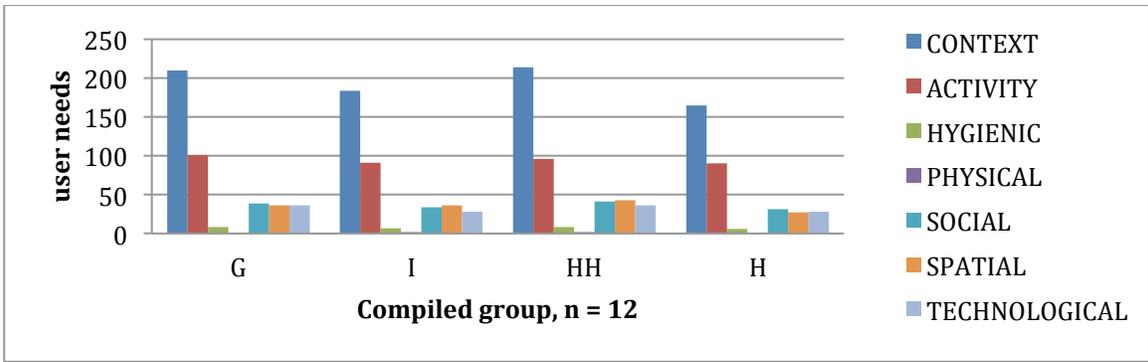


Figure 63. Distinct contextual needs for G, I, HH, and H groups

The GHH set was also superior to other groups in terms of contextual needs (Figure 64).

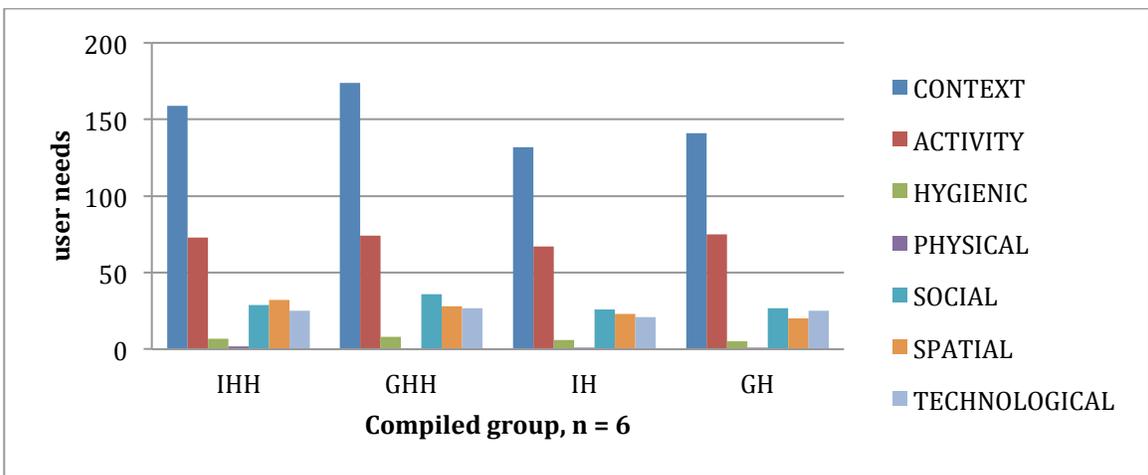


Figure 64. Distinct contextual needs for IHH, GHH, IH, and GH groups

See Section 5.4.3.1.3 for a detailed analysis of contextual needs across all groups.

5.3.1.4.3 Total user needs

A total of 369 user needs were identified across all compiled sets. In terms of a compiled requirements set, GHH (n = 267) identified more distinct user needs than all other groups (Table 28). GHH identified 25.5% more user needs than IH (n = 212), 20.4% more user needs than GH (n = 221) and 10.0% more user needs than IHH (n = 243). IHH identified 14.6% more user needs than IH and 10% more than GH.

Table 28. Percent differences in total needs per compiled set

| Compiled Set | Total Needs Comparison | | | |
|--------------|------------------------|---------|---------|---------|
| | IHH | GHH | IH | GH |
| | n = 243 | n = 267 | n = 212 | n = 221 |
| IHH | X | -9.0 | 14.6* | 10.0* |
| GHH | 10.0* | X | 25.9* | 20.8* |
| IH | -12.8 | -20.6 | X | -4.1 |
| GH | -9.0 | -17.2 | 4.3 | X |

* ≥ 10% difference

In terms of setting, the compiled information for group sessions (n = 323) contained 13.7% more user needs than the compiled information for individual sessions (n = 284), see Figure 65. In terms of questions, participants prompted with both habitual and hypothetical questions (n = 325) contributed 24.1% more distinct user needs than participants prompted with only habitual questions (n = 262), See Figure 65.

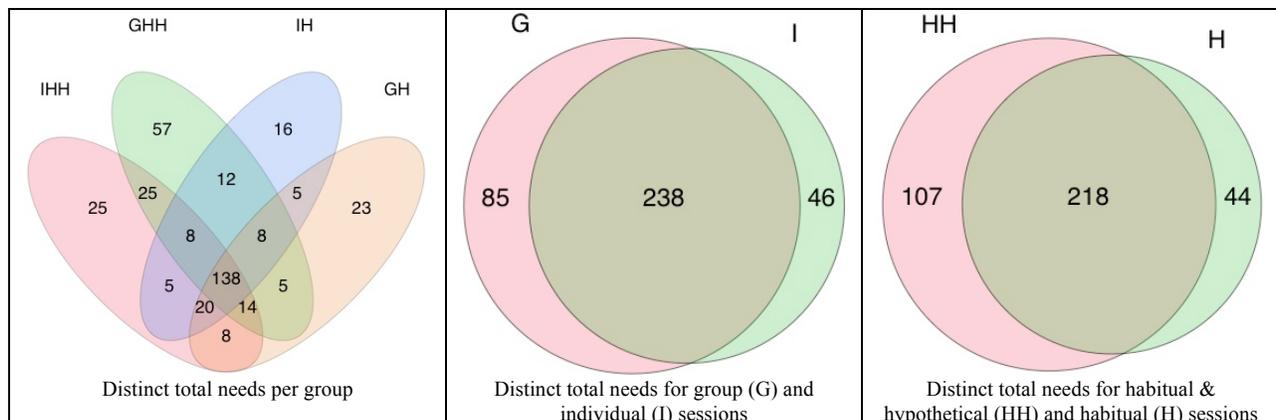


Figure 65. Venn comparisons for distinct total needs per group

5.3.1.4.4 Functional needs

A total of 126 functional needs were identified across all compiled sets. In terms of a compiled requirements set, GHH (n = 86) identified more distinct functional needs than all other groups (Table 29). GHH identified 21.3% more functional needs than IH (n = 71), 14.7% more user needs than GH (n = 75), and 10.3% more user needs than IHH (n = 78). IHH identified 10.0% more user needs than IH.

Table 29. Percent differences in functional needs per compiled set

| Compiled Set | Functional Comparison | | | |
|--------------|-----------------------|---------------|--------------|--------------|
| | IHH n = 78 | GHH n = 86 | IH n = 71 | GH n = 75 |
| IHH | X | -9.3 | 10.0* | 4.0 |
| GHH | 10.3* | X | 21.3* | 14.7* |
| IH | 9.0 | -17.4 | X | -5.3 |
| GH | -3.8 | -12.8 | 5.6 | X |

* ≥ 10% difference

Group sessions (n = 108) also elicited 14.9% more distinct functional needs than individual sessions (n = 94), See Figure 66. Habitual & Hypothetical prompts (n = 107) elicited 15.1% more distinct functional needs than sessions with just habitual prompts (n = 93), See Figure 66.

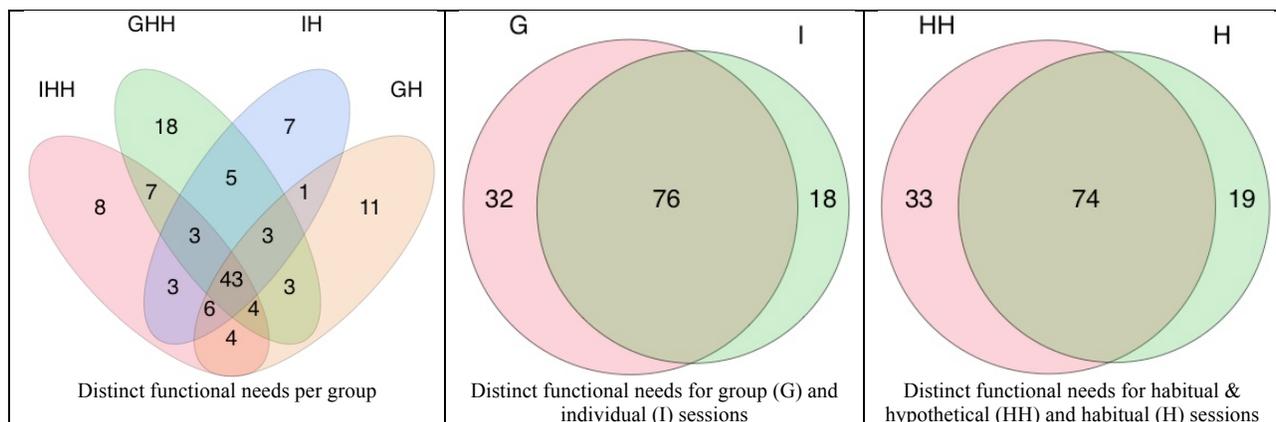


Figure 66. Venn comparisons for distinct functional needs per group

5.3.1.4.5 Usability needs

A total of 289 usability needs were identified across all compiled sets. GHH (n = 212) identified 24.7% more usability needs than IH (n = 170) and 20.5% more usability needs than GH (n = 176). The compiled requirements set for IHH (n = 198) was significantly different than both IH and GH sets. IHH elicited 16.5% more usability needs than IH and 12.5% more usability needs than GH (Table 30).

Table 30. Percent differences in usability needs per compiled set

| Compiled Set | Usability Comparison | | | |
|--------------|----------------------|----------------|---------------|---------------|
| | IHH n = 198 | GHH n = 212 | IH n = 170 | GH n = 176 |
| IHH | X | -6.6 | 16.5* | 12.5* |
| GHH | 7.1 | X | 24.7* | 20.5* |
| IH | -14.1 | -19.8 | X | -3.4 |
| GH | -11.1 | -17.0 | 3.5 | X |

* ≥ 10% difference

The compiled set for all group sessions (n = 253) was also significantly different than the compiled set for all individual sessions (n = 227). Group sessions elicited 11.5% more distinct usability needs than individual sessions (Figure 67).

Again, compiled requirements for habitual & hypothetical sessions (n = 257) surpassed the compiled requirements for habitual sessions (n = 206). HH sessions elicited 24.8% more distinct usability needs than H sessions (Figure 67).

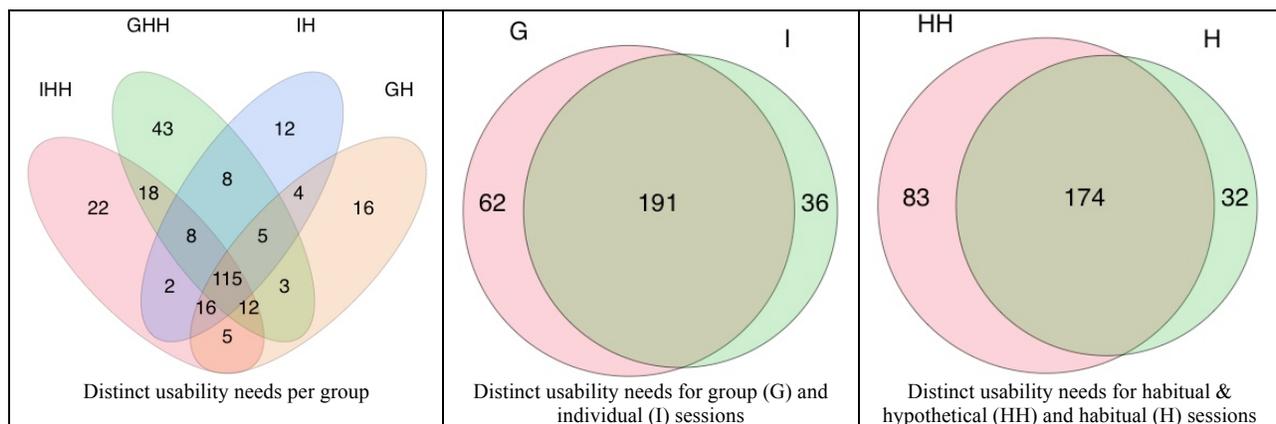


Figure 67. Venn comparisons for distinct usability needs per group

5.3.1.4.6 Effectiveness needs

GHH (n = 75) elicited 11.9% more distinct effectiveness needs than IH (n = 67). IHH (n = 74) also elicited 10.5% more effectiveness needs than IH (Table 31).

Table 31. Percent differences in effectiveness needs per compiled set

| Compiled Set | Effectiveness Comparison | | | |
|--------------|--------------------------|---------------|--------------|--------------|
| | IHH n = 74 | GHH n = 75 | IH n = 67 | GH n = 70 |
| IHH | X | -1.3 | 10.5* | 5.7 |
| GHH | 1.3 | X | 11.9* | 7.1 |
| IH | -9.5 | -10.7 | X | -3.4 |
| GH | -5.4 | -6.7 | 4.5 | X |

* $\geq 10\%$ difference

No significant differences were found between the compiled needs for individual (n = 88) and group (n = 96) sessions. However, HH (n = 91) elicited 11% more effectiveness needs than H (n = 82), See Figure 68.

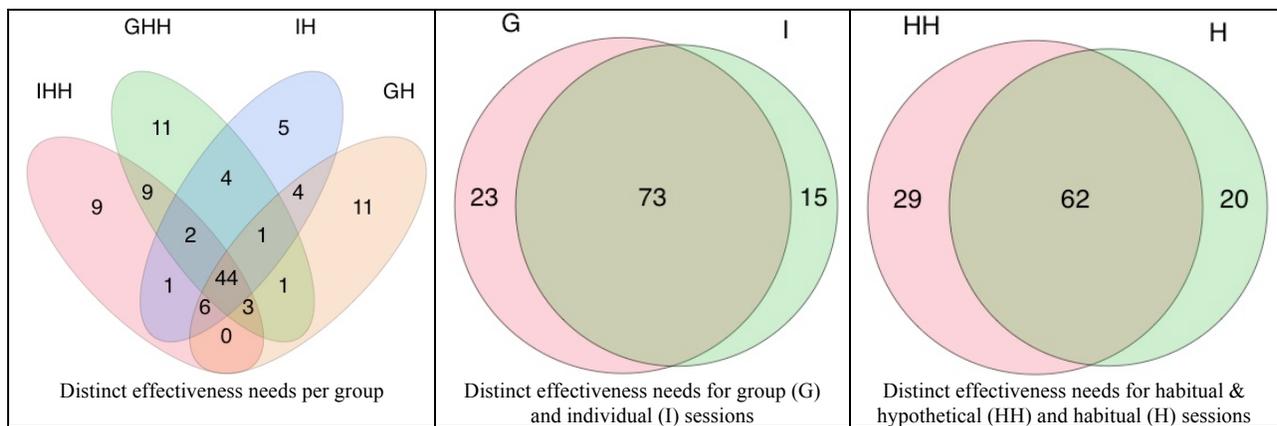


Figure 68. Venn comparisons for distinct effectiveness needs per group

5.3.1.4.7 Efficiency needs

GHH (n = 33) elicited 10% more efficiency needs than IHH (n = 30), See Table 32.

Table 32. Percent differences in efficiency needs per compiled set

| Compiled Set | Efficiency Comparison | | | |
|--------------|-----------------------|---------------|--------------|--------------|
| | IHH n = 30 | GHH n = 33 | IH n = 32 | GH n = 33 |
| IHH | X | -9.1 | -6.3 | -9.1 |
| GHH | 10.0* | X | 3.1 | 0.0 |
| IH | 6.7 | -3.0 | X | -3.0 |
| GH | 3.1 | 0.0 | 3.1 | X |

* ≥ 10% difference

Group (n = 45) sessions elicited 18.4% more distinct efficiency needs than individual (n = 38) sessions (Figure 69). No significant differences were found between the compiled needs for HH and H sessions.

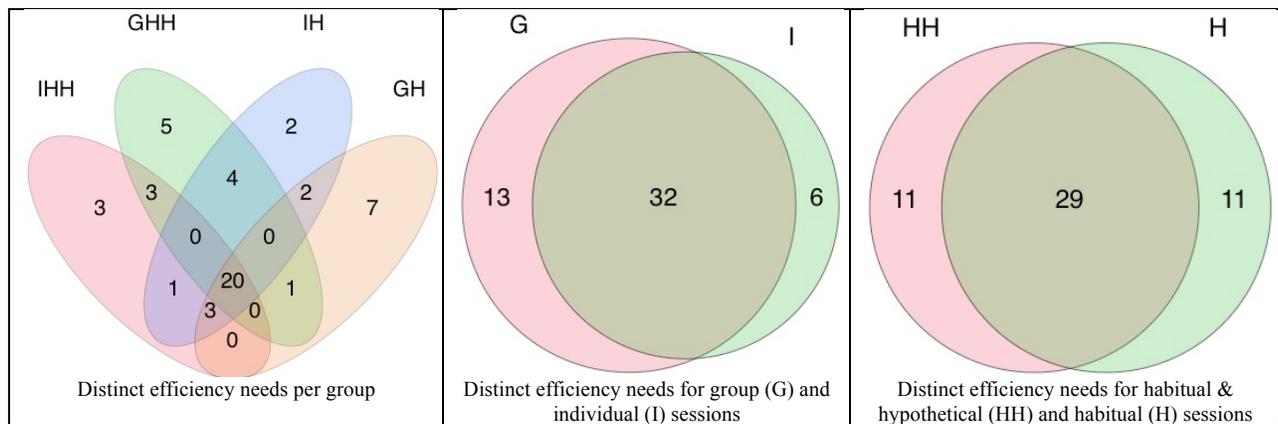


Figure 69. Venn comparisons for distinct efficiency needs per group

5.3.1.4.8 Satisfaction needs

In terms of a compiled requirements set, GHH (n = 73) identified more distinct satisfaction needs than all other groups (Table 33). GHH identified 40.4% more satisfaction needs than IH (n = 52), 19.7% more user needs than GH (n = 61), and 17.7% more user needs than IHH (n = 62). The compiled set for IH contained significantly less satisfaction needs than all other groups. The IHH set contained 19% more satisfaction needs than the IH set. Similarly, the GH set contained 17% more user needs than the IH set.

Table 33. Percent differences in satisfaction needs per compiled set

| Compiled Set | Satisfaction Comparison | | | |
|--------------|-------------------------|---------------|--------------|--------------|
| | IHH n = 62 | GHH n = 73 | IH n = 52 | GH n = 61 |
| IHH | X | -15.1 | 19.2* | 1.6 |
| GHH | 17.7* | X | 40.4* | 19.7* |
| IH | -16.1 | -28.8 | X | -14.8 |
| GH | -1.6 | -16.4 | 17.3* | X |

* ≥ 10% difference

The compiled set for all group sessions was also significantly greater than the compiled set for all individual sessions. Group session (n = 85) elicited 23.2 % more satisfaction needs than individual sessions (n = 69), See Figure 70.

Similarly, the compiled set for all HH sessions was significantly different than the compiled set for H sessions. HH sessions (n = 83) resulted in 25.8% more distinct satisfaction needs than sessions with only habitual prompts.

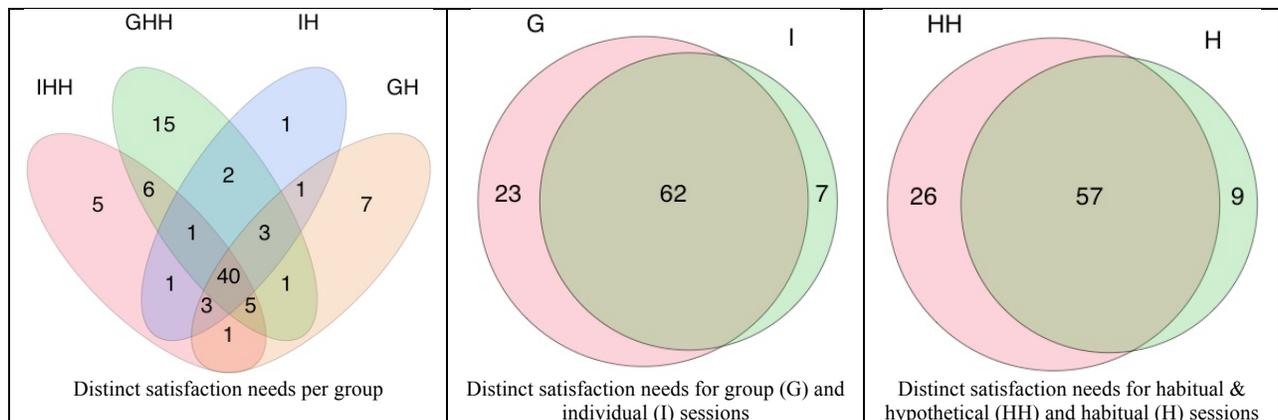


Figure 70. Venn comparisons for distinct satisfaction needs per group

5.3.1.4.9 Context-of-use

In terms of compiled contextual needs, sessions involving both habitual and hypothetical prompts fared better than sessions with just habitual prompts (Table 34). The compiled requirement set for IHH (n = 159) contained 20.5% more context needs than the compiled IH set (n = 132) and 12.8% more than the GH set (n = 141). Similarly, GHH (n = 174) elicited 31.8% more distinct context needs than IH and 23.4% more than GH.

Table 34. Percent differences in context needs per compiled set

| Compiled Set | Context-of-use Comparison | | | |
|--------------|---------------------------|----------------|---------------|---------------|
| | IHH n = 159 | GHH n = 174 | IH n = 132 | GH n = 141 |
| IHH | X | -8.6 | 20.5* | 12.8* |
| GHH | 9.4 | X | 31.8* | 23.4* |
| IH | -17.0 | -24.2 | X | -6.4 |
| GH | -11.3 | -19.0 | 6.8* | X |

* ≥ 10% difference

The compiled set for all group (n = 210) sessions also contained significantly more context needs than the set for individual (n = 184) sessions. Group sessions elicited 14.1% more distinct context needs than individual sessions, See Figure 71. Again, dual prompts resulted in a greater requirements set. Sessions with both habitual and hypothetical prompts (n = 214) elicited 29.7% more context needs than sessions with just habitual prompts (n = 165), See Figure 71.

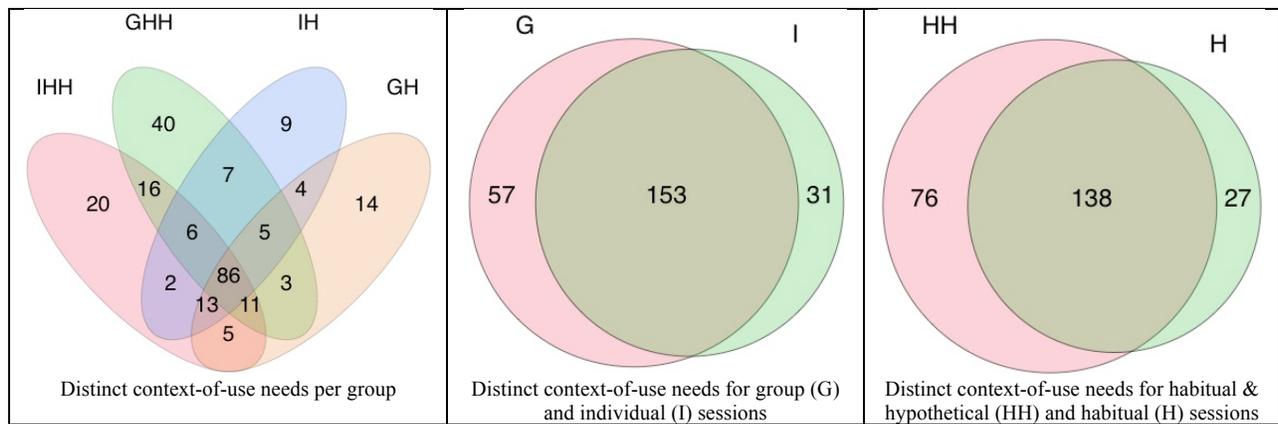


Figure 71. Venn comparisons for distinct context needs per group

5.3.1.4.10 Activity context

Both group sessions resulted in more distinct activity context needs than the compiled IH set (Table 35).

Table 35. Percent differences in activity context needs per compiled set

| Compiled Set | Activity Comparison | | | |
|--------------|---------------------|--------|--------|--------|
| | IHH | GHH | IH | GH |
| | n = 73 | n = 74 | n = 67 | n = 75 |
| IHH | X | -1.4 | 9.0 | -2.7 |
| GHH | 13.7* | X | 10.5* | -1.3 |
| IH | -8.2 | -9.5 | X | -10.7 |
| GH | 2.7 | 1.4 | 11.9* | X |

* $\geq 10\%$ difference

The GH set (n = 75) contained 11.9% more distinct activity needs than the IH set (n = 67). The GHH set (n = 74) also contained 10.5% more distinct activity needs than the IH set.

Group sessions (n = 101) resulted in 10.9% more activity needs than individual sessions (n = 91), See Figure 101. No significant differences were found between habitual & hypothetical (HH) and habitual (H) sessions (Figure 72).

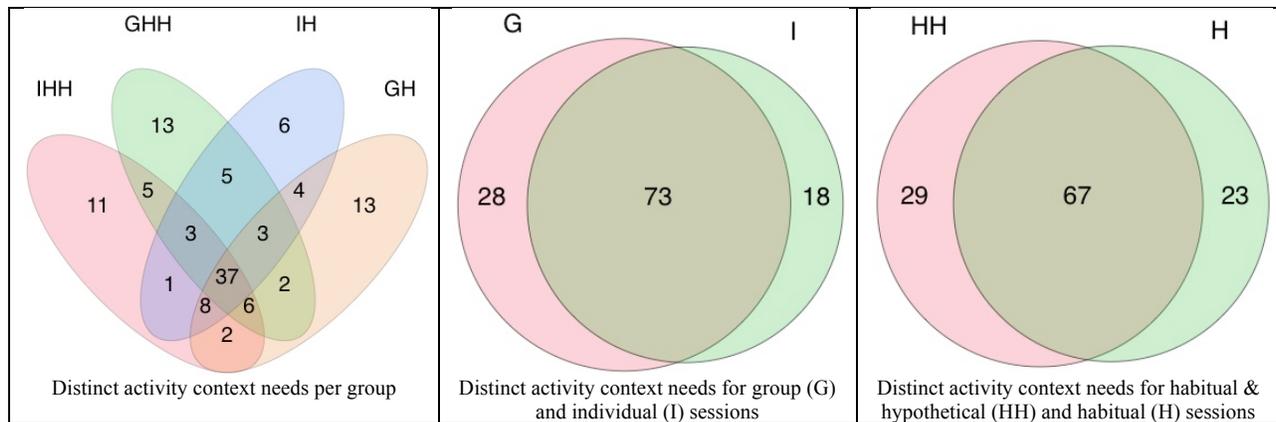


Figure 72. Venn comparisons for distinct activity context needs per group

5.3.1.4.11 Hygienic context

The quantity of hygienic context needs collected was insufficient for comparison between groups (Figure 73). The cutoff for analysis was 30 data points (5 user needs per person). Identified hygienic needs per group only ranged from 5 to 8 needs.

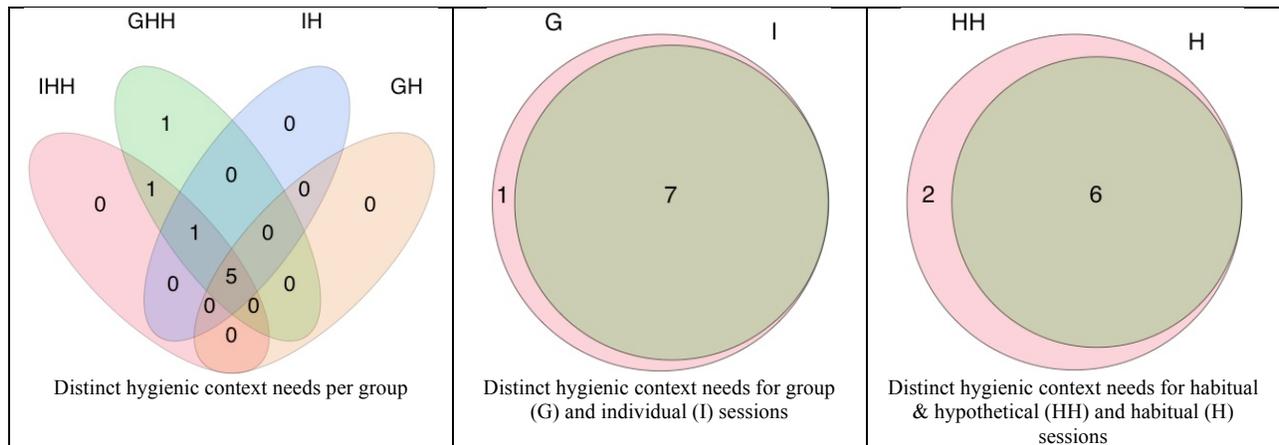


Figure 73. Venn comparisons for distinct hygienic context needs per group

5.3.1.4.12 Physical context

The quantity of physical context needs collected was insufficient for comparison between groups (Figure 74). Identified physical needs per group only ranged from 0 to 2.

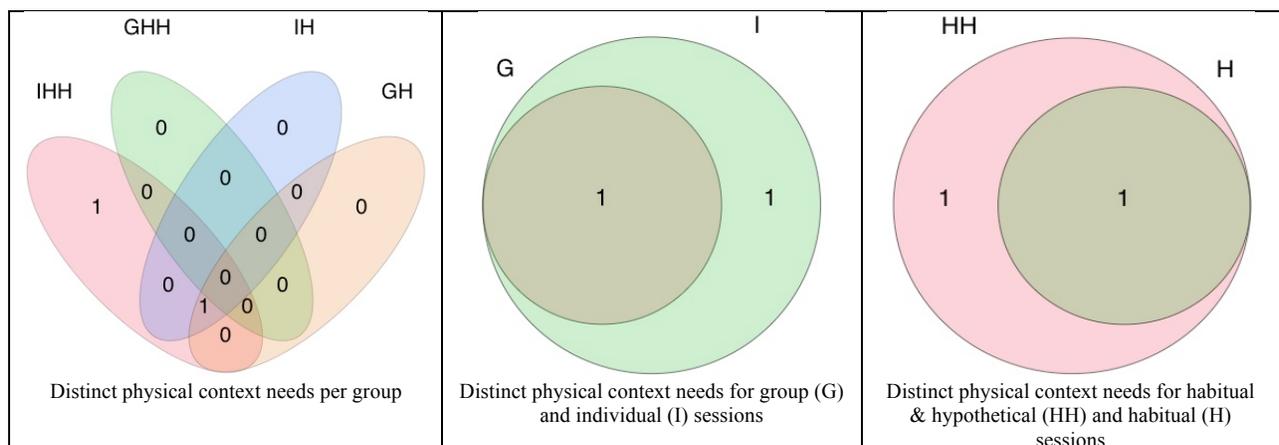


Figure 74. Venn comparisons for distinct physical context needs per group

5.3.1.4.13 Social context

In terms of a compiled requirements set, GHH (n = 36) identified more distinct social needs than all other groups (Table 36). GHH identified 38.5% more social needs than IH (n = 26), 33.3% more social needs than GH (n = 27), and 24.1% more social needs than IHH (n = 29). IHH identified 11.6% more user needs than IH.

Table 36. Percent differences in social context needs per compiled set

| Compiled Set | Social Comparison | | | |
|--------------|-------------------|---------------|--------------|--------------|
| | IHH n = 29 | GHH n = 36 | IH n = 26 | GH n = 27 |
| IHH | X | -19.4 | 11.6* | 7.4 |
| GHH | 24.1* | X | 38.5* | 33.3* |
| IH | -10.3 | -27.8 | X | -3.7 |
| GH | -6.9 | -25 | -3.8 | X |

* ≥ 10% difference

Group sessions (n = 39) elicited 14.7% more social context needs than individual sessions (n = 34). HH sessions (n = 41) elicited 32.3% more social context needs than H sessions (n = 31), See Figure 75.

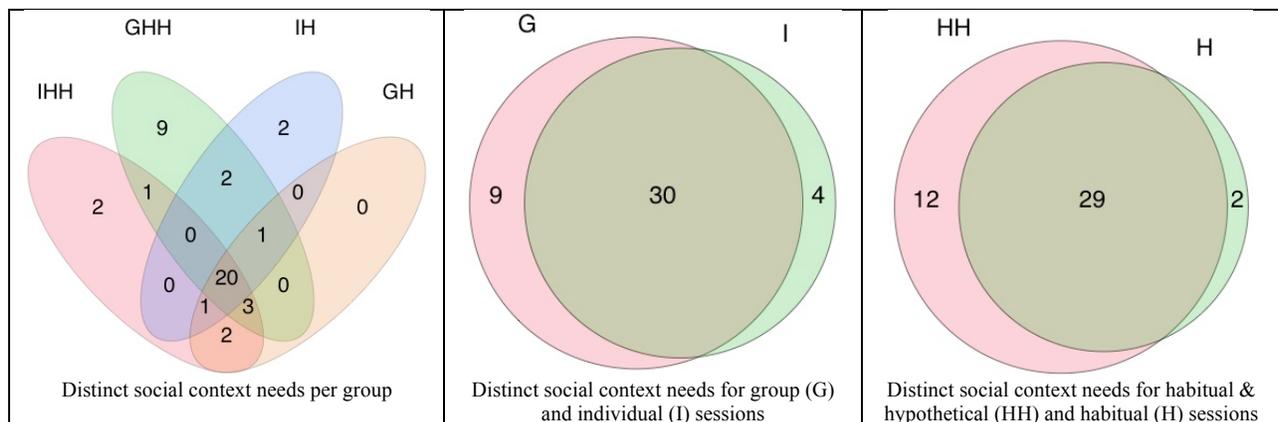


Figure 75. Venn comparisons for distinct social context needs per group

5.3.1.4.14 Spatial context

All compiled requirement sets were significantly different than each other (Table 37). Group GHH (n = 28) elicited 21.7% more user needs than IH (n = 23) and 40.0% more than GH (n = 20).

Table 37. Percent differences in spatial context needs per compiled set

| Compiled Set | Spatial Comparison | | | |
|--------------|--------------------|---------------|--------------|--------------|
| | IHH n = 32 | GHH n = 28 | IH n = 23 | GH n = 20 |
| IHH | X | 14.3* | 39.1* | 60.0* |
| GHH | -12.5 | X | 21.7* | 40.0* |
| IH | -28.1 | -17.9 | X | 15.0* |
| GH | -37.5 | -28.5 | -13.0 | X |

* ≥ 10% difference

Group IHH (n = 32) contributed more spatial needs than all other groups. The compiled IHH set contained 60% more spatial needs than GH set, 39.1% more than IH set, and 14.3% more than the GHH set. IH also contributed 15% more spatial needs than GH.

No significant differences were found between group and individual sessions in terms of the quantity of distinct spatial needs elicited. However, the HH set was significantly different than the H set (Figure 76). The compiled HH set contained 59.3% more spatial context needs than the H set.

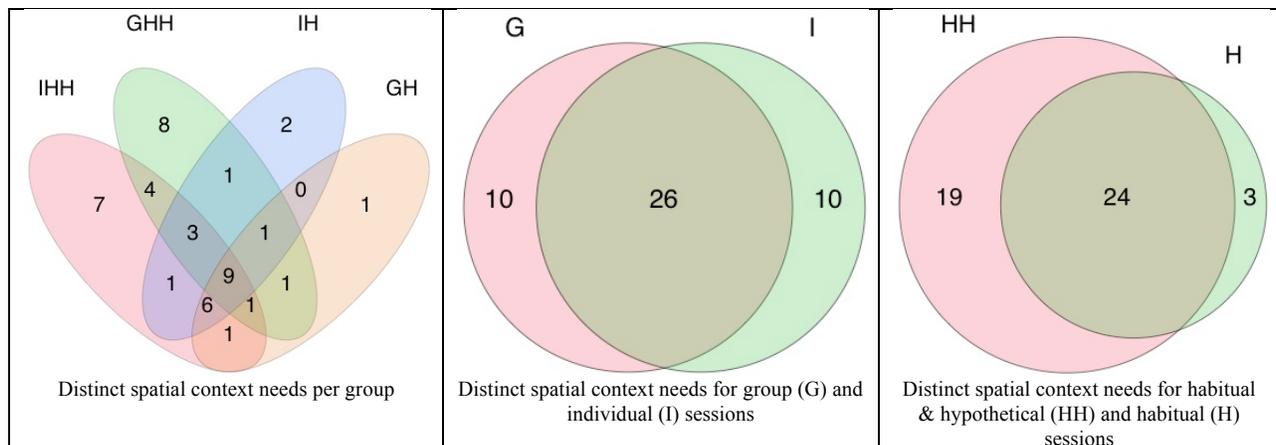


Figure 76. Venn comparisons for distinct social context needs per group

5.3.1.4.15 Technological context

The compiled IH set (n = 21) contained significantly less technological context needs than all other groups (Table 38). The GHH set (n = 27) was comprised of 28.6% more technological needs than the IH set. The IHH set (n = 25) and GH set (n = 25) both contained 19.1% more technological needs than IH.

Table 38. Percent differences in technological context needs per compiled set

| Compiled Set | Technological Comparison | | | |
|--------------|--------------------------|-------|-------|-------|
| | IHH | GHH | IH | GH |
| IHH | X | -7.4 | 19.1* | 0.0 |
| GHH | 1.1 | X | 28.6* | 8.0 |
| IH | -16.0 | -22.2 | X | -12.5 |
| GH | 0.0 | -7.4 | 14.3* | X |

* ≥ 10% difference

The compiled set for all group sessions (n = 36) contained 28.6% more technological context needs than the compiled set for individual sessions (n = 28). HH sessions (n = 36) also elicited more technological needs than H sessions (n = 28). The compiled HH set contained 28.6% more technological needs than the H set, See Figure 77.

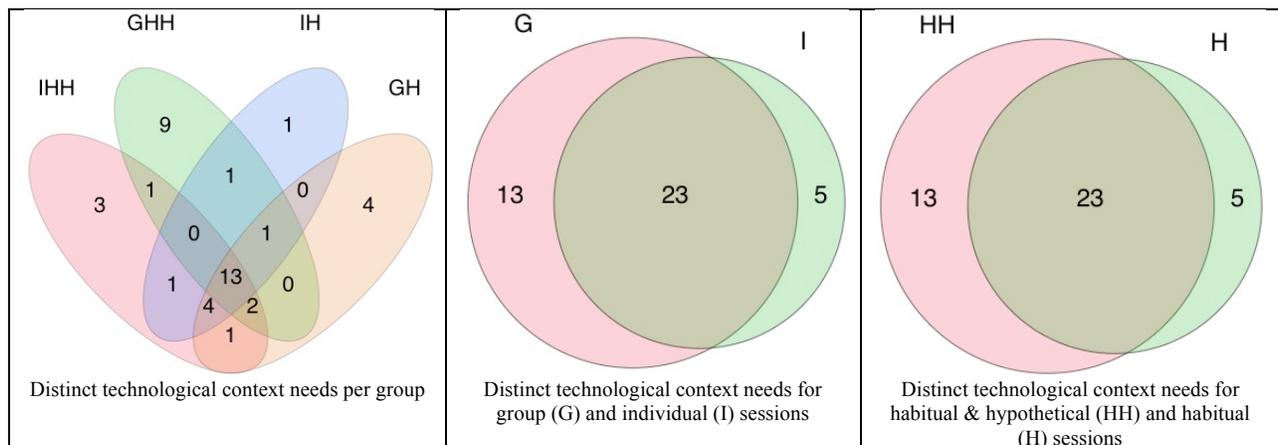


Figure 77. Venn comparisons for distinct technological context needs per group

5.3.1.4.16 Summary of findings – RQ1a-3 - Setting

Table 39. Summary of findings for RQ1a-3-Setting

| RQ1a-3 | Hypotheses | Finding |
|--------|----------------------|---|
| -1a | Supported | Group (G) participants collectively identified 13.7% more user needs than individual (I) participants. |
| -1b | Supported | G participants collectively identified 14.9% more functional needs than I participants. |
| -1c | Supported | G participants collectively identified 11.5% more usability needs than I participants. |
| -1d | Supported | No difference in the number of distinct effectiveness needs collectively identified by each group. |
| -1e | Unsupported | G participants collectively identified 18.9% more satisfaction needs than I participants. |
| -1f | Supported | G participants collectively identified 23.2% more satisfaction needs than I participants. |
| -1g | Supported | G participants collectively identified 14.1% more context needs than I participants. |
| -1h | Supported | G participants collectively identified 10/9% more activity needs than I participants. |
| -1i | Inconclusive | Insufficient hygienic needs were collected required for comparisons. |
| -1j | Inconclusive | Insufficient physical needs were collected required for comparisons. |
| -1k | Supported | G participants collectively identified 14.7% more social needs than I participants. |
| -1l | Supported | No difference for the number of distinct spatial needs collectively identified by participants in each group. |
| -1m | Not Supported | G participants collectively identified 28.6% more technological needs than I participants. |

5.3.1.4.17 Summary of findings – RQ1a-3 – Questions

Table 40. Summary of findings for RQ1a-3 - Questions

| RQ1a-3 | Hypotheses | Finding |
|--------|---------------------|---|
| -2a | Supported | HH participants collectively identified 24.1% more total needs than H participants. |
| -2b | Supported | HH participants collectively identified 15.1% more functional needs than H participants. |
| -2c | Supported | HH participants collectively identified 24.8% more usability needs than H participants. |
| -2d | Supported | No difference in the quantity of distinct effectiveness needs collectively identified by each group. |
| -2e | Supported | No difference in the quantity of distinct efficiency needs collectively identified by participants in each group. |
| -2f | Supported | HH participants collectively identified 25.8% more satisfaction needs than H participants. |
| -2g | Supported | HH participants collectively identified 29.7% more context needs than H participants. |
| -2h | Unsupported | No difference for the number of distinct activity needs collectively identified by participants in each group. |
| -2i | Inconclusive | Insufficient hygienic required for comparisons. |
| -2j | Inconclusive | Insufficient physical needs required for comparisons. |
| -2k | Supported | HH participants collectively identified 32.3% more social needs than H participants. |
| -2l | Unsupported | HH participants collectively identified 59.3% more spatial needs than H participants. |
| -2m | Unsupported | HH participants collectively identified 28.6% more technological needs than H participants. |

5.3.1.4.18 Summary of findings – RQ1a-3 – Setting*Questions

Table 41. Summary of findings for RQ1a-3 – setting*questions

| RQ1a-3 | Hypotheses | Finding |
|--------|----------------------------|---|
| -3a | Partially Supported | GHH identified more user needs than IHH, IH and GH. IHH identified more user needs than IH. GH was expected to identify more user needs than IH. |
| -3b | Partially Supported | GHH identified more functional needs than IHH, IH and GH. IHH identified more functional needs than IH. GH was expected to identify more functional needs than IH. |
| -3c | Partially Supported | GHH and IHH identified more usability needs than IH and GH. GHH and GH were expected to identify more usability needs than IH |
| -3d | Not Supported | GHH and GH identified more effectiveness needs than IH. No differences were expected. |
| -3e | Supported | No differences in the quantity of distinct efficiency needs. |
| -3f | Supported | GHH identified more satisfaction needs than IHH, IH and GH. IHH and GH identified more satisfaction needs than IH. |
| -3g | Partially Supported | GHH identified more context needs than IH and GH. GHH was expected identify more context needs than IHH as well. IHH identified more context needs than IH and GH. IHH was not expected to identify more context needs than GH. GH was expected to be greater than IH. |
| -3h | Partially Supported | GHH identified more activity needs than IH. GHH was expected identify more activity needs than IHH and GH as well. GH identified more activity needs than IH. IHH was expected to identify more activity needs than IH. |
| -3i | Inconclusive | Insufficient hygienic needs were collected required for comparisons. |
| -3j | Inconclusive | Insufficient physical needs were collected required for comparisons. |
| -3k | Partially Supported | GHH identified more social needs than IHH, IH and GH. IHH identified more social needs than IH. No difference in distinct social needs between GH and IH groups. GH was expected to be greater than IH. |
| -3l | Not Supported | All compiled spatial need sets were significantly different. No differences were expected. |
| -3m | Not Supported | IH identified significantly less technological needs than all other groups. No differences were expected. |

5.4 Discussion

5.4.1 *RQ1a-1: Impact of storytelling context (i.e., setting, questions) on the quantity of user needs elicited*

Group sessions elicited significantly more user needs than individual sessions for the majority of user needs categories. The only categories without significant differences between groups were hygienic and physical context. Overall, participants did not include hygienic and physical details in stories, which replicated findings of previous work (Gausepohl et al., 2011). It may be difficult to elicit nurses' stories that detail lapses in hygiene practices due to nurses' fear of professional ramifications. Although the most prevalent patient safety complication is hospital-acquired infection (Burke, 2003), we failed to elicit stories which detailed this type of patient safety concern. We suspect that our assurances of confidentiality did not provide enough support for nurses to freely share stories that could implicate themselves and/or the facility in a potentially litigious situation.

Although it is possible that storytelling as a method may not be adept at collecting hygienic and physical user needs, exploration of modifications to the protocol should be explored before ruling out storytelling entirely. As in previous work, our current protocol contained very broad questions, such as "Please tell me a story about an experience that you had where equitable care was an issue", as not to bias participant responses towards any particular user need category. However, in a non-research setting designers want to bias responses to collect desired information. For example, a designer interested in the role hygienic needs play in the design of an infusion pump may specifically prompt stakeholders to share stories related to cleanliness and infusion pumps. Alternatively, the protocol may retain the initial broad storytelling prompts with additional follow-up prompts to encourage discussion of hygienic and physical needs. For example, a designer could follow-up a story about resuscitating a hallway patient with prompts such as, "What features of the hallway set-up made treating this patient difficult?" Future work should explore how modifications to the storytelling protocol impact the ability to elicit hygienic and physical user needs.

The relative success of group sessions in comparison to individual sessions may be explained by differences in story details. Since the quantity of elicited narratives (i.e., total narratives, total habitual narratives, or total hypothetical narratives) was not found to be a main effect for the quantity of user needs elicited, one logical conclusion is that group sessions

collected more detailed stories than individual sessions. Why would storytellers in groups provide more details than those in individual sessions? Perhaps storytelling with a co-worker is a different experience than telling a story to an outside researcher. In fact, the storytelling experience in a group session may facilitate meaning-making, as narrative research has identified associations with meaning-making and elaborative disclosures of experiences (McLean, 2005; M. Pasupathi, 2007).

Another potential explanation for the differences in story detail (and associated identifiable user needs) between groups is the introduction of a co-worker as another listener in the session. Attentive listeners elicit longer and more detailed stories than inattentive listeners (Dickinson & Givon, 1995) so the inclusion of another attentive listener may have contributed to greater detail divulged in group sessions. When scheduling group storytelling sessions, designers should be aware of potential negative consequences of adding an inattentive listener to the discussion. We scheduled all group sessions to contain co-workers assigned to the same shift within one hospital location. In addition, the majority of group participants self-selected his/her storytelling cohort as two nurses typically volunteered for the research project at the same time. We suspect that the co-workers' familiarity enhanced the desire to be an attentive listener during the session. However, if we had scheduled sessions to include nurses working different shifts and/or different hospital locations we may have inadvertently introduced an inattentive listener to the session and lost the ability to elicit greater story detail.

The impact of collaborative remembering may be another factor that influenced the level of detail in narratives elicited during group sessions. We initially intended to analyze narratives at the participant level (i.e., consider each participant as an individual observation) to address RQ1, but we abandoned that approach when we discovered that the majority of group stories were co-constructed. Although our original intent was to collect "personal" narratives, due to the close relationships between our group storytellers, we found that many narratives reflected either well-known events (i.e., previously discussed stories) or shared experiences. This observed co-construction of narratives may be an important factor considering research exploring the impact of social context on story recall suggests that stories told with a cohort include greater detail and personal reflections than those told to an outside researcher (Hyman, 1994). Since more detailed stories facilitate the identification of user needs, designers should leverage collaborative remembering during group sessions. In addition to ensuring that groups consist of stakeholders

familiar / cordial with each other, designers may prompt group storytellers to specifically divulge shared experiences to encourage elaborative disclosure. For example, the prompt, “Please tell me a story about an experience that you both shared treating a crashing patient” would facilitate collection of user needs for a crash cart.

Although gender was not identified as a main effect for the amount of user needs elicited, it must be noted that narrative research has identified gender effects, which may have implications for the efficacy of storytelling as a requirements elicitation method in domains outside of healthcare. In terms of sharing personal experiences, women tend to talk more than men (Leaper & Ayres, 2007), which may make storytelling a method more suited to women-dominated domains, such as nursing. Gender differences have been also found in the content of shared emotional experiences. In comparison to men, women’s emotional narratives tend to contain more detail and emotional reflections (Ross & Holmberg, 1990). Designers should consider these potential gender differences, especially when the design problem requires the elicitation of negative experiences. For example, a designer tasked with creating a safer needle disposing system may consider initially recruiting women to share past unsafe experiences and/or near misses with needle disposal since women may share more detail of these unfortunate events.

Although setting (i.e., group, individual) differences were found for the majority of user need categories, question prompts (i.e., habitual & hypothetical, habitual) only influenced the quantity of activity needs elicited. Habitual sessions (i.e., IH, GH) elicited significantly more activity needs than sessions with both habitual and hypothetical questions (i.e., IHH, GHH). As hypothetical questions prompt storytellers to provide an ideal scenario as a counterpoint to a previously discussed activity, it is expected that HH storytellers would spend more time discussing a smaller set of activities than storytellers prompted with only habitual questions. The greater quantity of activity needs contributed by Groups IH and GH can be attributed to the relative freedom to discuss a greater variety of topics (i.e., activities) than participants in Groups IHH and GHH. Designers should consider the current design stage when choosing which types of questions to incorporate in his/her storytelling protocol. During initial problem space exploration, a protocol containing only habitual questions is more appropriate as it allows a broader exploration of the problem space through a varied discussion of activities. However, when a design focus has been determined, the protocol should be altered to include hypothetical

questions in an effort to reveal the gap between the current and ideal experience for the chosen activity of interest.

Although main effects for setting and question type were found, no interaction effect was found for the quantity of user needs elicited. No significant differences in quantity were found for Groups GHH, GH, IHH, or IH for any user needs categories, which supported our hypothesis. As our research questions are grounded within a requirements engineering and design perspective, the quantity of user needs elicited per person is not a primary indicator of elicitation success. We judge the efficacy of an elicitation method based on its ability to elicit a greater quantity of user needs in terms of a compiled set of stakeholder's responses. The impact of session context on the compiled set of user needs was explored in RQ1a-2 and RQ1a-3.

Session duration was an unexpected factor effect as we originally intended for all storytelling sessions to last approximately one hour. However, session duration had a broad range (min = 28, max = 98 minutes) since we prompted participants for each IOM quality aim until he/she was unable to share any more stories relating to that particular aim. Not surprisingly, long duration sessions resulted in the collection of significantly more user needs than short duration sessions. However, some unexpected results were found for the interaction between setting and time. Group sessions of average duration elicited significantly more total user needs, usability needs, and context-of-use needs than individual sessions of average duration. Since group sessions elicit a greater quantity of usability and context-of-use needs than individual sessions, usability engineers may consider group sessions a superior approach. However, scheduling difficulty for group sessions is a tradeoff that should also be considered by designers. The overhead associated with scheduling group sessions (e.g., coordinating work schedules, increased cancellations) may counteract the benefits of eliciting a greater quantity of usability needs.

5.4.2 RQ1a-2: Impact of storytelling context on the breadth of the compiled set

All hypotheses for question RQ1b were supported. As expected, no significant differences were found for the breadth of user needs collected during storytelling sessions. Regardless of assignment to either a group or individual session, participants' addressed 12 out of the 13 categories on average (min = 11, max = 13). Sixteen of the 22 sessions (72.7%) failed to elicit physical context needs from participants. Several explanations for this failure are possible. As previously discussed in Section 5.4.1, storytelling as a method may not be suited to

the collection of physical context needs as storytellers may not voluntarily describe aspects of the physical environment without additional prompting. Considering that more detailed narratives are shared during collaborative storytelling, group sessions should have elicited more physical context information than individual sessions. Since both group and individual sessions failed to elicit details describing the physical environment, we suspect that storytellers do not provide this level of detail when prompted with broad questions, such as those used during this study. In fact, the use of the word “experience” in our prompts, which is common phrasing in phenomenological research, may have biased participants to divulge more details relating to the event and/or social relationships than to concentrate on physical details.

Participants may have also been biased by our chosen location for storytelling sessions, which was a private room within the ER department. Participants may not have felt it necessary to describe physical aspects of the working environment while actually sitting within the ER. Although the room was private, the noise of the ER was still apparent through overhead announcements and general hospital noise, such as the sounds of equipment beeping. With the noise a constant presence, participants may not have felt it necessary to describe a noisy working environment in his/her story. Since all ERs were a secured unit, the majority of participants escorted the primary researcher from the waiting room to the room within the ER department. In retrospect, participants may have viewed this interaction as a tour of the department. Participants may have been biased from describing physical aspects of the ER after witnessing the researcher walk through the ER.

Another possible explanation for our inability to identify physical context needs may be the analysis procedure for user needs identification. As other contextual needs were identified, the problem may be with the IEC 62366 (2007) examples we used to describe physical needs in our analysis protocol. The design standard included climate conditions, acceleration, light level, and ambient noise as aspects of the physical context. We suspect that these examples may not adequately encourage the identification of specific user needs from participant responses. The examples seem to assume observation as the primary data collection method, which may in fact be the easiest method to collect user needs relating to the physical context as we were unable to elicit this information through storytelling.

From a requirements engineering perspective, the success of an elicitation measure is partially judged by the breadth of the compiled information across stakeholders. No differences

in the breadth of compiled user needs were found between groups as all groups covered all possible categories. However, designers should be cognizant of the fact that perfect breath is only one measurement of the quality of a user needs set. Although all groups touched upon the topic of physical context needs, the information elicited during this research did not provide an exhaustive description of the physical context. Considering only two physical context needs (i.e., ventilation adequate, assign patients in rooms close together) were identified during the course of this research, this finding highlights the importance of depth as another measure of user needs set quality. Section 5.4.3 provides a discussion highlighting the findings for this additional measure of quality.

5.4.3 RQ1a-3: Impact of storytelling context on the depth of the compiled user need set

Our findings for RQ1a-3 support the creation of recommendations for how to best manipulate the storytelling context to elicit the desired information. As designers are not typically assigned tasks such as, “Collect the best compiled list of efficiency needs”, our recommendations represent decision trees for specific design tasks. We focus our recommendations on the following design tasks since they represent common goals in the User Centered Design (UCD) process, which was the impetus for this research:

- (a) Identify a design problem (i.e., explore the problem space)
- (b) Understand an unfamiliar domain (i.e., specify context of use)
- (c) Incorporate usability into the design process (i.e., formative usability approach)
- (d) Validate design (i.e., summative usability approach)

Although RQ1a-3 explored the changes in depth due to main effects and interaction effects, analyses outside our original scope, which explored additional permutations of the compiled user need sets were required to create accurate designer recommendations. As comparisons between G, I, HH, and H were outside of our original research scope, our initial findings would not be able to provide decision support for situations in which these methods would be options. In an effort to provide comprehensive decision trees for the design goals listed above, we performed additional analyses comparing these four groups. To ensure that our recommendations would represent an exhaustive comparison of all possible method combinations, we created two additional groupings, Mixed1 and Mixed2. Mixed1 represents the combination of method IH and method GHH. Mixed2 represents the combination of method IHH and method GH. We

limited our analyses to 3 of the 13 user needs categories as we determined that knowledge of differences in functional, usability, and context-of-use depth would adequately support decisions for the identified design tasks. First, we present our findings for these additional analyses in Section 6.5.3.1. Explanations for the decision trees for the design tasks are provided in Section 6.5.3.2.

5.4.3.1 Depth comparisons between compiled groups utilizing mixed storytelling methods (i.e., G, I, HH, H, Mixed1, Mixed2)

Triangulation of methods is frequently recommended in requirements literature as a means to leverage the benefits of multiple methods in an effort to elicit the most comprehensive set of user needs from stakeholders as possible. To ensure that our recommendations consider opportunities for triangulation, we compared the depth of user needs resulting from the compilation of 2 method types. A summative review of the methods used within each group is provided in Table 42. The quantities of functional, usability, and context-of-use needs identified by these groups are provided in Table 43.

Table 42. Methods used within each compiled grouping of user needs

| Compiled User Needs Set | Methods (n = 2) | Sessions (min = 6, max = 12) | Participants (N = 12) |
|--------------------------------|----------------------------------|---|--|
| G | GHH | (n = 3) | (n = 6) |
| | GH | (n = 3) | (n = 6) |
| | | <i>N = 6</i> | <i>N = 12</i> |
| I | IHH | (n = 6) | (n = 6) |
| | IH | (n = 6) | (n = 6) |
| | | <i>N = 12</i> | <i>N = 12</i> |
| HH | GHH | (n = 3) | (n = 6) |
| | IHH | (n = 6) | (n = 6) |
| | | <i>N = 9</i> | <i>N = 12</i> |
| H | GH | (n = 3) | (n = 6) |
| | IH | (n = 6) | (n = 6) |
| | | <i>N = 9</i> | <i>N = 12</i> |
| Mixed 1 | GHH | (n = 3) | (n = 6) |
| | IH | (n = 6) | (n = 6) |
| | | <i>N = 9</i> | <i>N = 12</i> |
| Mixed 2 | GH | (n = 3) | (n = 6) |
| | IHH | (n = 6) | (n = 6) |
| | | <i>N = 9</i> | <i>N = 12</i> |

Table 43. Quantity of functional, usability, and context needs per compiled set

| Set | User Need Category | | | |
|---------------|--------------------|------------|-----------|----------------|
| | Total | Functional | Usability | Context-of-use |
| G | 323 | 108 | 253 | 210 |
| I | 284 | 94 | 227 | 184 |
| H | 262 | 93 | 206 | 165 |
| HH | 325 | 107 | 257 | 214 |
| Mixed1 | 313 | 103 | 246 | 202 |
| Mixed2 | 284 | 96 | 226 | 185 |

5.4.3.1.1 Depth of functional needs

The compiled G set (n = 108) had significantly greater depth of functional needs than the I set (n = 94), the H set (n = 94) and the Mixed2 set (n = 96). The G set contained 14.1% more distinct needs than the I set, 16.1% more than the H set and 12.5% more than the Mixed2 set (Table 44).

Table 44. Percent differences in functional needs per compiled set

| Compiled Set | Functional Needs Comparison | | | | | |
|----------------|-----------------------------|----------|----------|-----------|---------------|---------------|
| | G | I | H | HH | Mixed1 | Mixed2 |
| | n = 108 | n = 94 | n = 93 | n = 107 | n = 103 | n = 96 |
| G* | X | 14.9* | 16.1* | 1.0 | 4.9 | 12.5* |
| I | -13.0 | X | 1.1 | -12.2 | -8.7 | -2.1 |
| H | -13.9 | -1.1 | X | -13.1 | -9.7 | -3.2 |
| HH* | -1.0 | 13.9* | 15.1* | X | 3.9 | 11.5* |
| Mixed1* | -4.5 | 9.6 | 10.8* | -3.7 | X | 7.3 |
| Mixed2 | -11.1 | 2.1 | 3.2 | -10.3 | -6.8 | X |

* ≥ 10% difference

Group HH (n = 107) also contributed a greater depth of functional needs than some other groupings, according to our operational definition of “significant difference” as a 10% increase between groups. The compiled HH set contained 15.1% more distinct functional needs than

Group H (n = 93), 13.9% more than Group I (n = 94), and 11.5% more than the Mixed2 set (n = 96).

5.4.3.1.2 Depth of usability needs

The significant differences found for the compiled G set in terms of functional needs depth, was replicated for the depth of usability needs. The compiled G set (n = 253) also contained more distinct usability needs than the H set (n = 206), the I set (n = 226), and the Mixed2 set (n = 226), representing a 22.8%, 11.5%, and 12.0% increase, respectively (Table 45).

Table 45. Percent differences in usability needs per compiled set

| Compiled Set | Usability Needs Comparison | | | | | |
|----------------|----------------------------|--------------|--------------|---------------|-------------------|-------------------|
| | G n = 253 | I n = 227 | H n = 206 | HH n = 257 | Mixed1 n = 246 | Mixed2 n = 226 |
| G* | X | 11.5* | 22.8* | 1.6 | 2.9 | 12.0* |
| I* | -10.3 | X | 10.2* | -11.7 | -9.2 | 0.0 |
| H | -18.6 | -9.2 | X | -19.8 | -16.3 | -13.3 |
| HH* | 1.6 | 13.2* | 24.8* | X | 4.5 | 13.7* |
| Mixed1* | -2.8 | 8.3 | 19.5* | -4.3 | X | 8.9 |
| Mixed2 | -10.7 | -0.4 | 9.7 | -12.1 | -8.1 | X |

* ≥ 10% difference

Similar to findings for functional needs, the HH set (n = 257) had significantly greater depth than the H (n = 206), Mixed2 (n = 226), and I (n = 227) sets. The HH set contained 24.8% more distinct usability needs than the H set, 13.7% more than the Mixed2 set, and 13.2% more than the I set.

However, additional significant differences not found in functional depth were found for usability depth. Both the I set (n = 227) and the Mixed1 set (n = 246) contained significantly more distinct usability needs than the H set (n = 206). The Mixed1 set contained 19.5% more distinct usability needs than the H set. The I set barely met the definition for significant differences with a 10.2% increase in usability needs than the H set.

Although percent comparisons do not identify potential differences in usability depth between the G, I and Mixed1 sets, the Venn diagram (Figure 78) reveals that the Mixed1 set did not contribute any unique information. For example, the G set identified 18 usability needs not identified by either Mixed1 or I, while the I set identified 22 unique usability needs.

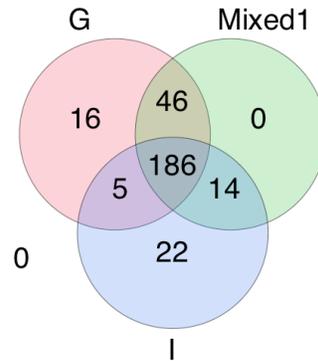


Figure 78. Comparison of usability depth for G, HH, and Mixed1 sets

5.4.3.1.3 Depth of context-of-use needs

The depth findings for functional and usability needs were replicated for the depth of context-of-use needs. The G set (n = 210) also contained significantly more context-of-use needs than the H (n = 165), I (n = 184), and Mixed2 (n = 185) sets. The compiled context-of-use needs for the G set represented a 27.2% increase over the H set, a 14.1% increase over the I set, and a 13.5% increase over the Mixed2 set (Table 46).

Table 46. Percent differences in context-of-use needs per compiled set

| Compiled Set | Context-of-use Needs Comparison | | | | | |
|----------------|---------------------------------|---------|---------|---------|---------|---------|
| | G | I | H | HH | Mixed1 | Mixed2 |
| | n = 210 | n = 184 | n = 165 | n = 214 | n = 202 | n = 185 |
| G* | X | 14.1* | 27.2* | -1.9 | 4.0 | 13.5* |
| I* | -12.4 | X | 11.5* | -14.0 | -8.9 | 1.0 |
| H | -21.4 | -10.3 | X | -22.9 | -18.3 | -10.8 |
| HH* | 1.9 | 16.3* | 29.7* | X | 5.9 | 15.7* |
| Mixed1* | -3.8 | 9.8 | 22.4* | -5.6 | X | 9.2 |
| Mixed2* | -11.9 | 1.0 | 12.1* | -13.5 | -8.4 | X |

* ≥10% difference

The previous findings for the HH set depth in the functional and usability categories were also replicated for context-of-use. The HH set (n = 214) contained significantly more context-of-use needs than the H set (n = 165), the I set (n = 184), and the Mixed2 set (n = 185). The HH set contained 29.7% more distinct context-of-use needs than the H set. Differences between the HH set and the other two sets were similar. The HH set represented a 16.3% increase over the I set and a 15.7% increase over the Mixed2 set.

Similar to the functional and usability depth findings, the H set (n = 165) contained less depth than the Mixed1 set (n = 202) and the I set (n = 184). An additional finding was found with the H set containing significantly less depth in context-of-use than the Mixed2 (n = 185), See Figure 79.

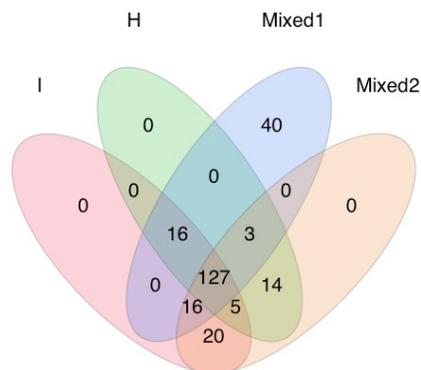


Figure 79. Distinct context needs for I, H, Mixed1, Mixed2

The Mixed1 set contained 22.4% more distinct context-of-use needs than the H set. Differences between the H set and the I set and the Mixed2 set were not as profound. The I set represented an 11.5% increase over the H set. The Mixed2 represented a slightly higher percentage with a 12.1% increase in distinct context-of-use needs

5.4.3.2 Decision support tools

The depth findings detailed in Sections 5.4.3.1.1 through 5.4.3.1.3 provide decision rules that can be used in conjunction with a decision tree to provide decision support tools to designers working on one of the four main design goals identified in Section 5.4.3. These decision support tools, in conjunction with the guidelines and traceability support (See Section 7.1.3), comprise the design guidance created as a result of this work. The decision support tools are represented in the format of a decision tree (Quinlan, 1986), which has been used within healthcare to model patient behaviors (Oh & Park, 2004), as well as provide diagnosis support to healthcare

practitioners (Aspinall, 1979). As the UCD tasks all involve the collection of functional, usability, and context-of-use information, the rules provide decision support for the choosing the best storytelling context for eliciting this type of information (Table 47).

Table 47. Decision rules for functional, usability, and context needs

| User need category | Decision rules | Notation |
|---------------------------|---|--------------------------------------|
| Functional | Choose G or HH over I, H, Mixed 2 methods | $(G HH) > (I H Mixed2)$ |
| | Choose GHH over GH or IHH methods | $GHH > (GH IHH)$ |
| | Choose GHH or IHH over IH methods | $(GHH IHH) > IH$ |
| Usability | Choose G or HH over I and Mixed2 methods | $(G HH) > (I Mixed2)$ |
| | Choose G, HH, I or Mixed1 over H methods | $(G HH I Mixed1) > H$ |
| | Choose GHH or IHH over IH or GH methods | $(GHH IHH) > (IH GH)$ |
| Context | Choose G or HH over I and Mixed2 methods | $(G HH) > (I Mixed2)$ |
| | Choose G, HH, I, Mixed1 or Mixed 2 over H methods | $(G HH I Mixed1 Mixed2) > H$ |
| | Choose GHH or IHH over IH or GH methods | $(GHH IHH) > (IH GH)$ |

The Phase 2 analyses resulted in decision rules that follow an inheritance pattern for functional, usability, and context-of-use needs. For example, the decision rules for the usability category contain all of the functional rules with a few additions. Likewise, the context-of-use category inherits all of the usability rules and contains an additional rule.

5.4.3.2.1 Baseline decision tree

A baseline decision tree was created to determine which methods are available to designers within a variety of potential design constraints (Figure 80). As designers do not work within ideal conditions, our decision tree provides recommendations for real-world situations in which the available methods are constrained by time and/or scheduling issues. Our decision tree accounts for two issues frequently cited in design research, which were also found to be problematic in the course of this study: limited time to conduct user research and potential issues

with group sessions (e.g., scheduling issues, hierarchical issues between stakeholders). To allow for trade-offs between designers' goals, our decision tree is not restricted to binary decisions. For example, in response to the decision "Groups problematic?", designers may select "Maybe" as an answer. In contrast to the "No" response, the "Maybe" path for this decision only excludes method combinations that include the sole use of group storytelling sessions. This provides more flexibility for designers as the remaining available methods include combinations of group and individual sessions. A summary of all decisions, potential responses, and exclusion criteria for each tree node is available in Appendix B.8. A brief example, which details the decision rules for nodes 1.1.1 through 1.1.3, is provided in Table 48.

The baseline decision tree, in conjunction with the decision rules detailed in Table 46, supports the creation of decision support tools for the four common design tasks. Decision support tools for *Identify a design opportunity*, *Understand an unfamiliar domain*, *Incorporate usability into the design process* and *Validate the design* are presented in Sections 5.4.3.2.2 through 5.4.3.2.5.

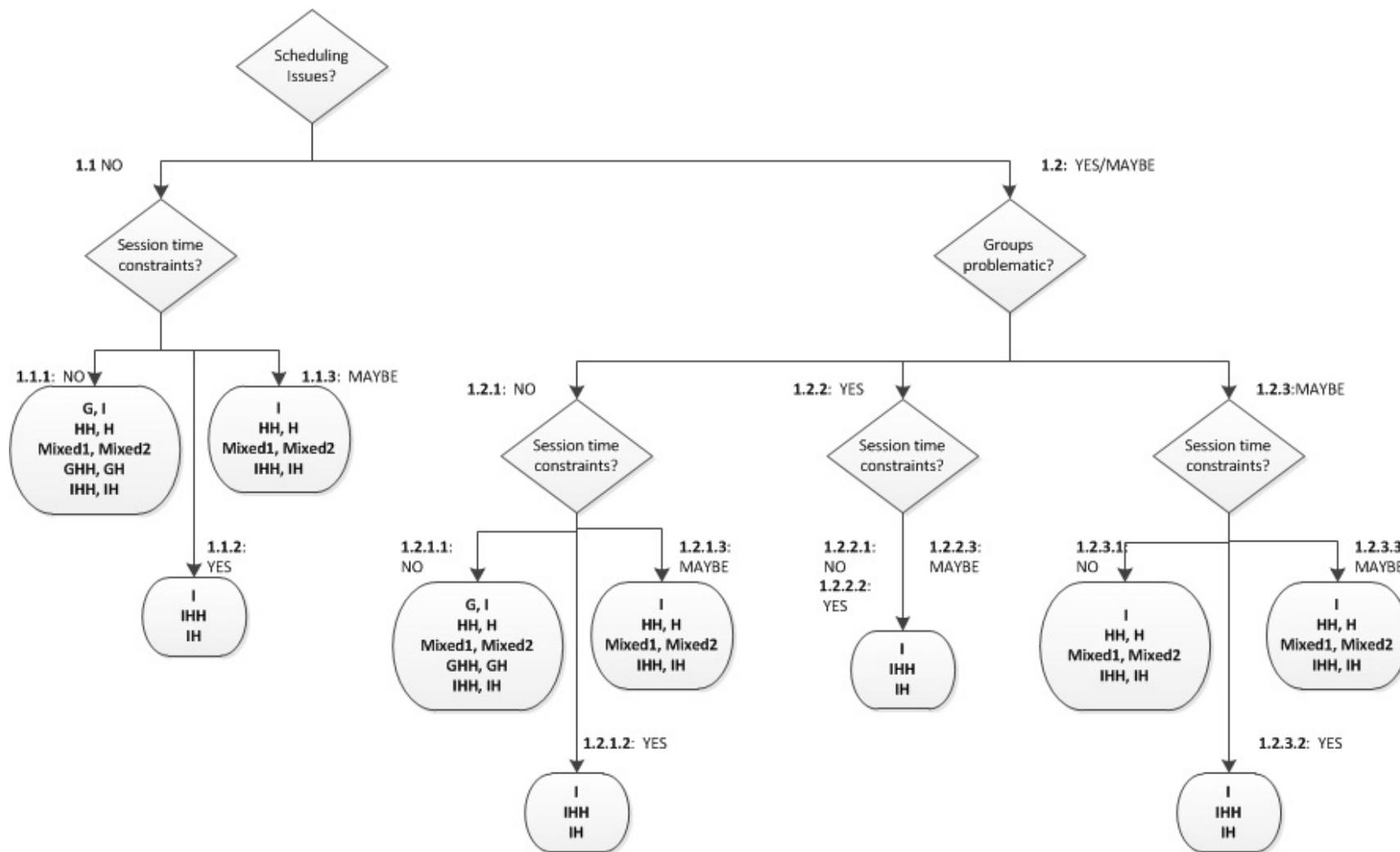


Figure 80. Baseline decision tree

Table 48. Exclusion rules for the creation of the baseline decision tree

| Potential methods (inputs) | Node | Question | Decision | Exclusion rule | Potential methods (outputs) |
|---|-------|---------------------------|----------|--|--|
| G, I HH, H Mixed1, Mixed2 GHH, GH IHH, IH | 1.1 | Scheduling Issues? | No | None | G, I HH, H Mixed1, Mixed2 GHH, GH IHH, IH |
| G, I HH, H Mixed1, Mixed2 GHH, GH IHH, IH | 1.1.1 | Session time constraints? | No | NONE | G, I HH, H Mixed1, Mixed2 GHH, GH IHH, IH |
| G, I HH, H Mixed1, Mixed2 GHH, GH IHH, IH | 1.1.2 | Session time constraints? | Yes | Exclude all group sessions since group sessions were significantly longer than individual sessions | I IHH IH |
| G, I HH, H Mixed1, Mixed2 GHH, GH IHH, IH | 1.1.3 | Session time constraints? | Maybe | Exclude combinations that solely use groups. | I HH, H Mixed1, Mixed2 IHH, IH |

5.4.3.2.2 Decision support tool: Identify a design opportunity

Design opportunities are identified during problem space exploration. The ability to collect a broad range of functional and contextual needs impacts the success of the exploration exercise. Successful elicitation of functional needs supports the identification of what the system and/or person needs to accomplish as through the design. The collection of contextual information further elucidates the differing users and environments for which the design must function. As the gathering of functional and contextual needs is critical during the identification of a design opportunity, designers benefit from guidance in how to alter storytelling sessions to maximize likelihood of eliciting this information. A synthesis of the Phase 1 and Phase 2 results resulted in the identification of decision rules (Table 47), exclusion criteria (Appendix B.9) and the creation of a baseline decision tree (Figure 80). A decision support tool for the selection of storytelling methods when the designer's goal is to identify a design opportunity (Figure 81) was created through the application of decision rules for functional and context-of-use needs to the baseline decision tree.

Since the decision rules follow an inheritance pattern (i.e., the functional rules are a subset of the contextual rules), this decision support tool provides guidance for selecting a storytelling method that targets both functional and contextual information.

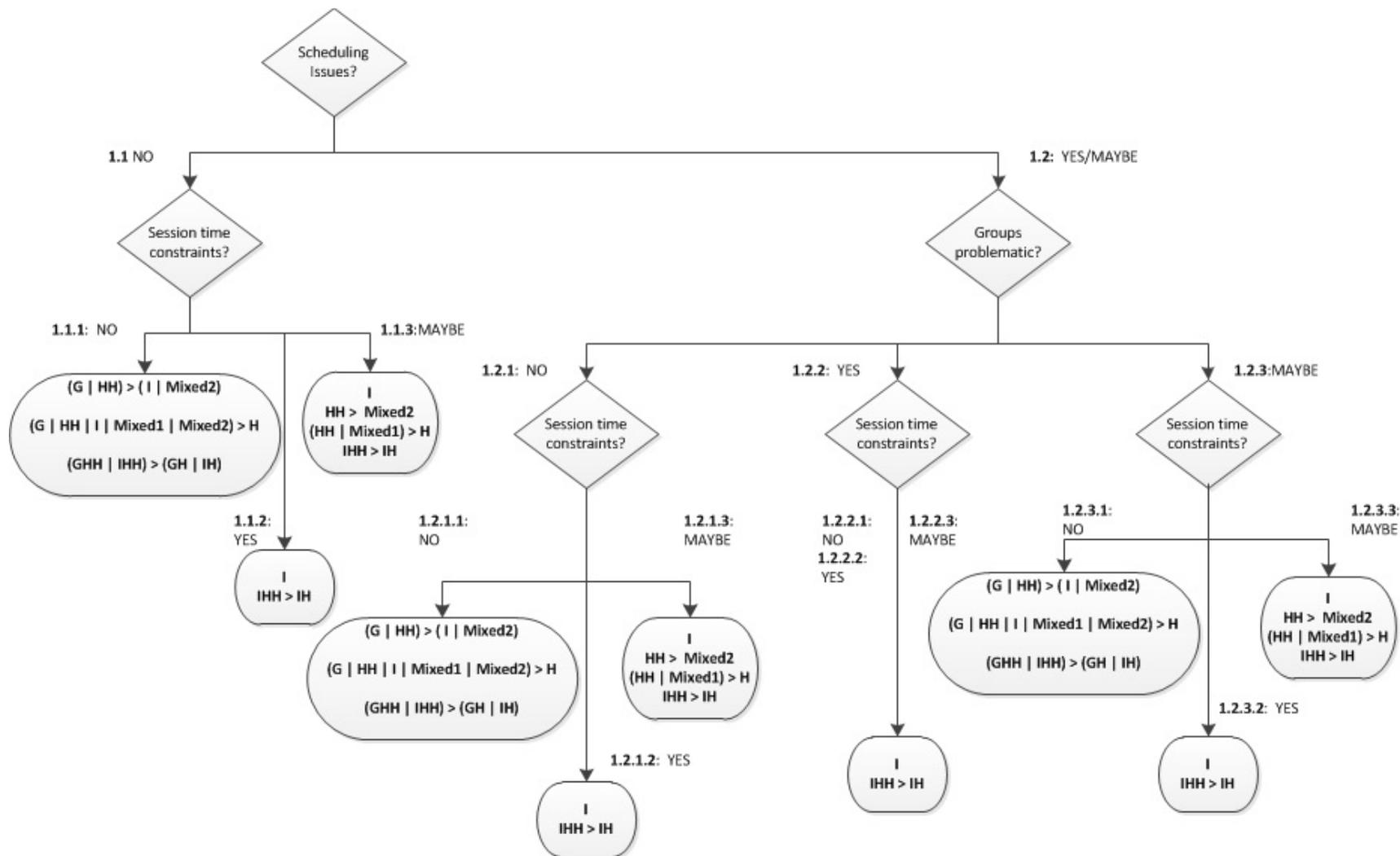


Figure 81. Decision support tool for the selection of a storytelling method for use during problem space exploration (i.e., Identify a design problem)

An additional decision support tool (Figure 82), which applies the decision rules for functional needs only, supports cases in which functional needs are valued over contextual information. For example, a designer familiar with a given domain may give precedence during problem exploration to functional needs over contextual information.

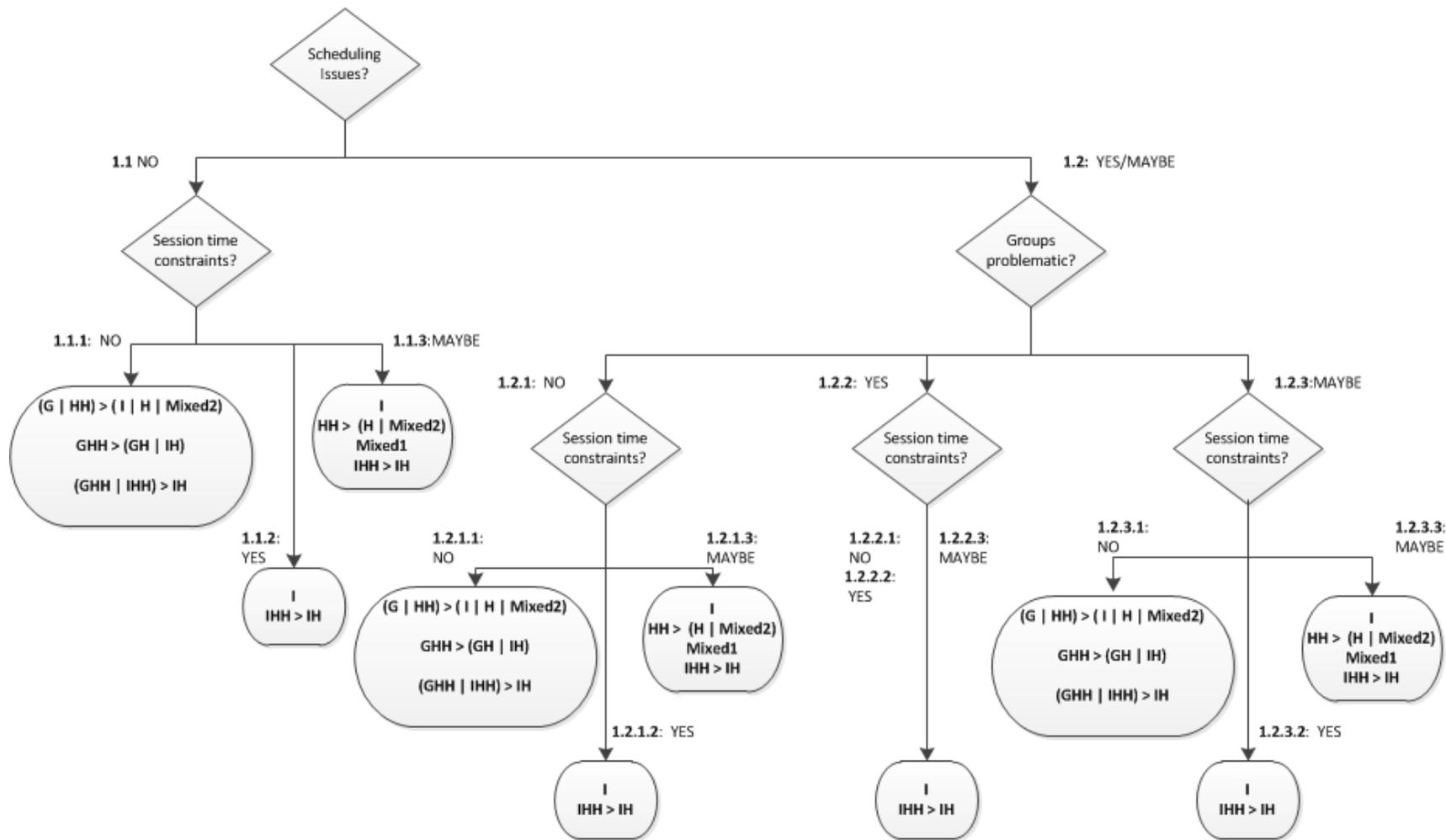


Figure 82. Decision support tool for the selection of a storytelling method when an emphasis on functional needs is required

5.4.3.2.3 Decision support tool: Understand an unfamiliar domain

The collection of contextual information supports the understanding of an unfamiliar domain. Since the decision support tool for identifying a design opportunity (Figure 81) also focuses on the collection of contextual information, it also provides designers with guidance for choosing a storytelling methodology that best aids the designer in understanding an unfamiliar domain.

5.4.3.2.4 Decision support tool: Incorporate usability into the design process

Design standards suggest a formative usability approach to design in which usability needs are identified early in the design process. During this design task, functional needs and associated usability needs provide valuable design insights. Application of the decision rules for the usability category results in the decision support tool for selecting an appropriate storytelling method while incorporating usability into the design process (Figure 83).

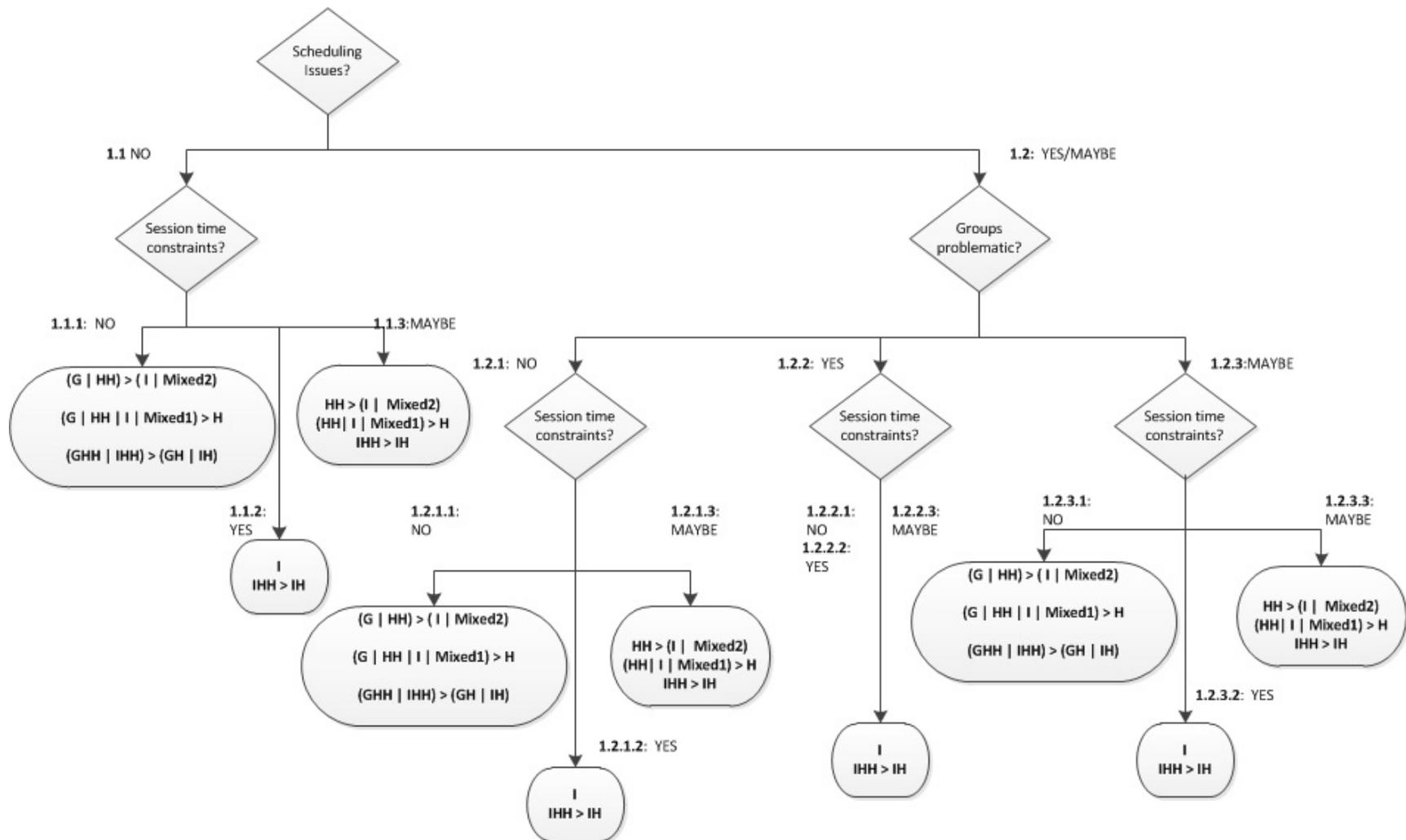


Figure 83. Decision support tool for the selection of a storytelling method for use during formative usability design

5.4.3.2.5 Decision support tool: Validate design

Designers may be tasked with validating designs in cases where formative usability was not possible (i.e., summative usability), whether due to time or budgetary constraints. A designer goal during design validation is to collect usability needs so the design can be tested against the collected needs. To create benchmarks for usability testing, designers must first elicit usability information. The decision support tool for a formative usability task (Figure 83) also provides guidance for designers forming a storytelling protocol during a summative usability task since both tasks require the collection of usability needs.

5.4.4 *Limitations*

Interpretations of the Phase 2 results must consider several limitations of the study. In terms of data collection, the user needs collected as part of this study may be biased as all participants worked within one corporate healthcare organization. Although we enhanced the study's qualitative breadth through the use of four research sites within this organization, the user needs may not adequately reflect needs at other hospital locations. In addition, all research sites were located within the same state so the stories, and associated user needs, may not be generalized to a national level. Our results may more accurately reflect consulting design as real-world designers may limit user needs analyses to particular organizations and/or locations.

Interpretation of the RQ1a results must consider the small sample size and unequal treatment groups. Although narratives were collected from 28 participants, statistically we only had 22 observations due to the collaborative storytelling in groups, which prevented analysis at the participant level. We performed due diligence by interpreting the fit of the generalized linear models used for identification of main and interaction effects. For example, we interpreted the appropriateness of the model through interpretations of residual plots and the Pearson's chi square statistic. The interpretation of the generalized linear model fit characteristics supports our contention that even with a small sample size we collected enough data for the means to converge and for the test to be appropriate.

In addition, difficulties in participant recruitment within this domain negatively affected our sample size. Although we found relative success recruiting nurses through the use of a research champion within each hospital location (Gausepohl, 2010), scheduling group sessions

was particularly problematic due to organizational characteristics within each hospital. For example, inconsistent work schedules coupled with three different 12-hour shifts made scheduling group sessions very difficult as potential participants were unable to plan sessions in advance since he/she did not yet have next week's work schedule. The sheer difficulty in conducting research within healthcare is evident by the resources required (i.e., 9 months, 4 research locations) to obtain 29 participants.

In terms of the narrative analysis procedure, the use of three different groups to analyze participant transcripts is another limitation of this work. We do not have a measure of inter-team reliability outside of the common narratives used during coder training, which required all teams reach .80 agreement with the ideal coding results to complete. However, due to the vast amount of textual data associated with this work, the use of three narrative analysis teams was necessary to provide a timely report to each hospital location. Our selection of Labov & Waletzky's (1967) structural analysis approach as our method for narrative analysis may be considered a limitation as well. Although this method is highly cited in the literature, it is possible that another narrative analysis method may have provided a better source narrative for later user needs analysis. The comparison between alternative narrative analysis methods is a potential avenue for future work.

Another potential limitation to the study is the iterative thematic analysis procedure used to specify user needs within narratives. Although we presented this procedure during a conference poster presentation (Gausepohl, Beaton, et al., 2011) and received positive feedback from industry experts, this procedure may not be the most effective method to specify needs. However, the use of independent coders and weekly reconciliation meetings with a judge mitigates this threat to internal validity. In addition, the successful use of the procedure by student design teams in Phase 3 (See Chapter 6) enhances its validity.

Unfortunately, the unequal sample sizes between individual ($n = 8$) and group ($n = 3$) storytelling sessions also introduced a limitation for RQ1a-3, which explored the compiled set of user needs. Comparisons between compiled sets representing interaction (i.e., IHH, IH, GHH, GH) and main effects (G, I, HH, H) were not possible due to the unequal sample sizes. For example, the collected data did not support the creation of a balanced G set that could be compared with IHH.

This chapter provided an overview of a theoretical exploration of storytelling. Chapter 6 provides an overview of the Design + Storytelling framework's practical application in a design task.

CHAPTER 6. FRAMEWORK IN PRACTICE (PHASE 3)

Chapter 4 and Chapter 5 presented theoretical findings that support practical design guidance for the manipulation of the storytelling context during a given user-centered design stage. The purpose of the study's third and final phase was to investigate the impact of the Design + Storytelling framework during a design task.

Student design teams within an upper-level engineering design course were used as proxies for professional designers. Students role-played designer roles similar to Laporti et. al. (2009). Although previous work (Atman et al., 2007) suggests that students spend less time than designers during information gathering, this work mitigated this confound as students were tasked with the analysis of ER nurses' stories previously collected during Phase 1. As part of regular coursework, engineering students participated in four lab exercises, which culminated in the creation of a conceptual design. Each conceptual design represented a proposed solution to an identified design problem informed by ER nurses' stories (Figure 84).

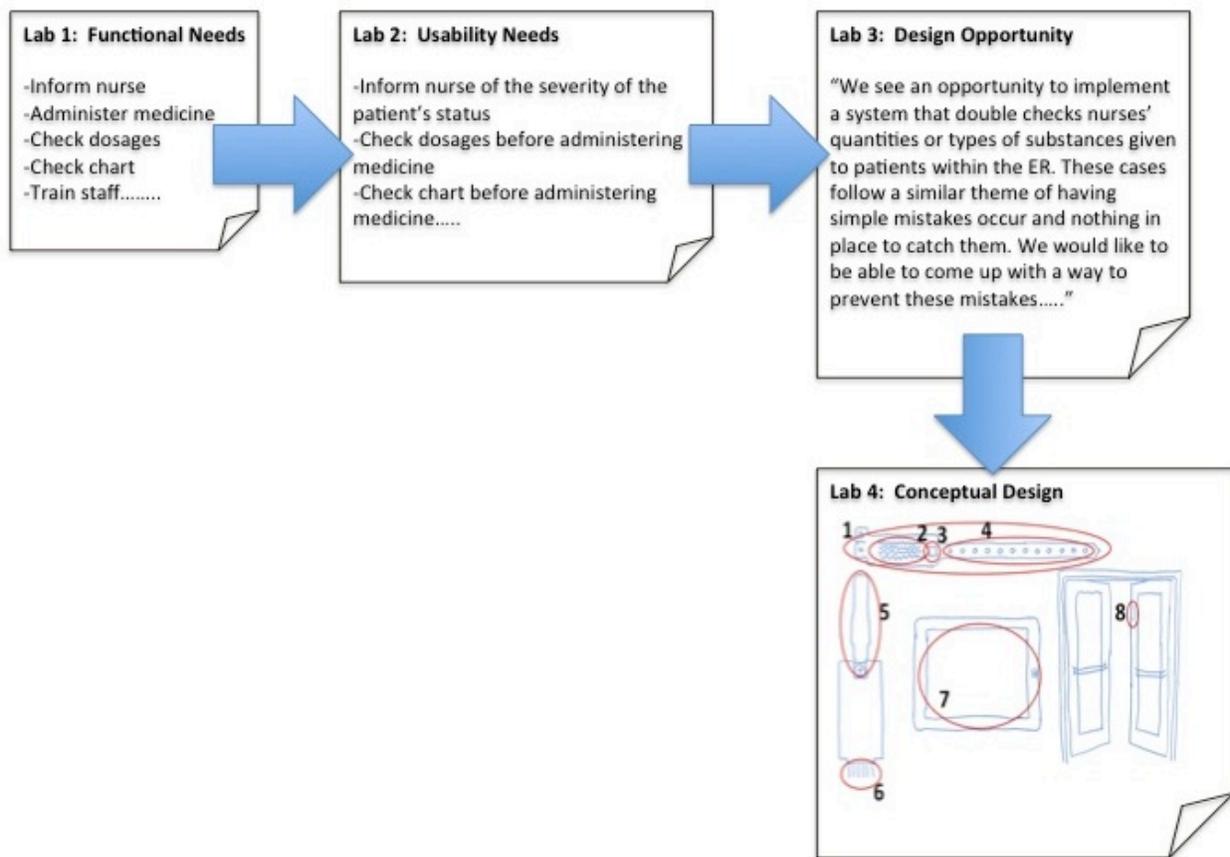


Figure 84. Students' conceptual designs addressed a problem identified in previous labs

Stakeholder experts with experience in requirements engineering, usability engineering, product design, and/or medical device design were recruited to critique students' projects. All critiques were conducted on de-identified versions of design projects after the completion of the course.

Section 6.1 details the research questions addressed by Phase 3.

6.1 Research Questions

RQ2: What impact does the framework have on design?

RQ2a: What is the impact of the framework's analysis instructions on designers' ability to identify user needs?

RQ2a-1: How are the user need sets identified by designers provided with analysis instructions (i.e., W teams) different than sets identified without instructions (i.e., WO teams)?

RQ2a-2: How are the user need sets identified by designers provided with the framework's analysis instructions (i.e., W teams) different than the set identified by qualitative analysts?

RQ2b: What is the impact of the framework's analysis instructions on designers' ability to identify a design opportunity?

6.2 Method

Similar to Phases 1 and 2, a mixed methods approach was used to address the Phase 3 research questions. Quantitative comparisons between the number of functional, usability, and context-of-use needs were conducted to address RQ2a-1. Descriptive characteristics of each team's set of user needs were qualitatively compared with the ideal set to address RQ2a-2. Quantitative and qualitative methods were also employed for RQ2b. Experts' rankings and questionnaire scores were statistically compared to discern differences between groups. Thematic analysis of experts' statements within written critiques provided additional insight into the identified differences between groups.

6.2.1 Summary of design

The research design was a between-subjects design to allow for comparisons between treatments. Each four-person design team was assigned to one of two groups:

W Teams: Design teams provided with transcripts (i.e., practitioners' stories from Phase 1), ***with*** the framework's analysis instructions (i.e., narrative analysis instructions, grammar rules for user need specification)

WO Teams: Design teams provided with transcripts (i.e., practitioners' stories from Phase 1) and basic instructions ***without*** the framework's analysis instructions

6.2.2 Participants

6.2.2.1 Student designers

Forty students, who comprised 10 design teams, were recruited from two course sections (i.e., Section A, Section B) of the Virginia Tech course *Introduction to Human Factors* offered within the Industrial and Systems Engineering department. The majority of participants ($n = 35$) were junior level engineering students and the remaining participants ($n = 5$) were senior level engineering students. Average participant age was 21.3 years of age (min = 19, max = 42).

Sixteen participants (10 male, 6 female) were recruited from Section A and 24 participants (16 male, 8 female) were recruited from Section B. As Section B was randomly selected to receive the framework’s instructions, all Section B teams were W teams and all Section A teams were WO teams. Four W teams were created in Section A and six WO teams were created in Section B. Participants were assigned to each four-person design team based on demographic data (i.e., gender, design experience) collected via questionnaire (Appendix C). All teams contained at least one female student and at least one student with experience in design, requirements engineering, and conceptual design creation. All W teams had experience working with healthcare, while only two of the WO teams reported healthcare experience (Table 49). Surprisingly, the majority of students reported experience with design, but not with activities typically associated with design, such as requirements and usability engineering.

Table 49. Percent of student experience reported per team

| Team | Experience Level | | | | |
|------|------------------|--------------------------|-----------------------|----------------------------|------------|
| | Design | Requirements engineering | Usability engineering | Conceptual design creation | Healthcare |
| WO1 | .75 | .25 | .25 | .75 | 0 |
| WO2 | .75 | .50 | .25 | .75 | 0 |
| WO3 | .25 | .25 | .25 | .25 | .25 |
| WO4 | 1.0 | .25 | 0 | .50 | .25 |
| W1 | .75 | .50 | .50 | .75 | .25 |
| W2 | 1.0 | .25 | .25 | .75 | .25 |
| W3 | 1.0 | .25 | .25 | 1.0 | .25 |
| W4 | 1.0 | .50 | .50 | .50 | .25 |
| W5 | .75 | .25 | .25 | .25 | .25 |
| W6 | 1.0 | .25 | .25 | .50 | .25 |

Since experience between teams was unbalanced, the composition of each design team was used to create additional groupings for experience during RQ2a-1 analyses. For example, teams were assigned to either a “low experience” or “high experience” group for each category based on a median-split.

6.2.2.2 Stakeholder experts

Three participants were recruited to act as stakeholder experts and provide critiques of students’ conceptual designs after the semester was completed. Two of the stakeholder experts were male and one was female. Experts’ age ($M = 32.3$, $SD = 1.2$ years) was fairly homogenous. All experts had usability experience ($M = 6.7$, $SD = 3.1$ years). Only one expert reported proficiency in all remaining experience categories (i.e., requirements engineering, product design, and medical device design). On average, experts’ experience in requirements engineering ($M = 3.3$, $SD = 3.5$, min = 0, max = 7 years) and product design ($M = 3$, $SD = 2.7$, min = 4, max = 5 years) surpassed experience in medical device design ($M = 1.3$, $SD = 1.5$, min = 0, max = 3 years).

6.2.3 Recruitment

6.2.3.1 Student designers

Participants in each section were recruited during a brief in-class presentation within the first month of the semester. The primary researcher displayed the study announcement (Appendix C.2) via a PowerPoint slide and distributed IRB forms (Appendix C.1) and demographic questionnaires (Appendix C.4) for students to review. The primary researcher explained that involvement in the study did not require any additional coursework as the study only involved post-hoc analyses of lab assignments. The researcher explained that participating students would be assigned to lab teams based on demographic data while non-participating students would be randomly assigned to design teams. Students were asked to read the IRB forms and return them at the start of the next class period if he/she chose to participate. The course instructor was not present or involved during participant recruitment as not to influence student participation in the study.

6.2.3.2 Stakeholder experts

The selection criteria for stakeholder experts were: (1) a minimum of master's level degree from an engineering, design, or computer science university program and (2) a minimum of two years of practical design experience. A radial sampling approach was used to recruit stakeholder experts. Recent master's and doctoral graduates with industry experience were initially contacted via email for potential inclusion in the study. The email contained a brief description of the study, a copy of the informed consent form (Appendix C.1), and a link to an online demographic questionnaire (Appendix C.6). Informed consent was obtained upon submission of the online questionnaire, which contained the phrase "By completing and submitting this questionnaire I agree to be part of the study." Two experts were recruited from a direct email and one participant was recruited through an email forward.

6.2.4 Questionnaires

6.2.4.1 Student designers

A demographic questionnaire (Appendix C.4) was used to collect students' gender, age, major, academic level, and design experience.

6.2.4.2 Stakeholder experts

A demographic questionnaire (Appendix C.6) collected experts' age, gender, and years-of-experience in usability engineering, requirements engineering, product design, and medical device design.

A questionnaire (Appendix C.8) was used to collect experts' reviews of each team's final conceptual design submission. The questionnaire contained 11 likert-scale questions, which asked experts to state agreement in response to a statement about the design's apparent functionality, usability, and appropriateness within an emergency room setting. For example, experts were asked to select agreement on a 5-point likert-scale for the statement "The design addresses the identified functional need(s)". In addition, the questionnaire prompted experts to provide written critiques of each design's functionality, usability, and overall appropriateness within an ER setting.

An additional questionnaire collected experts' rankings of each conceptual design in comparison to all other designs reviewed (Appendix C.9). The questionnaire collected rankings for each design's functionality, usability, and overall appropriateness within an ER setting.

All questionnaires were made available to stakeholder experts via Virginia Tech's instance of Qualtrics survey software available at <http://qualtrics.com>.

6.2.5 *Materials*

6.2.5.1 Student designers

Design teams were provided with a de-identified transcript containing patient and practitioner stories collected from six ER nurses during Phase 1. All stories were habitual stories collected in a group setting (i.e., Method GH). In an effort to create a course assignment that could be completed by four team members during a month-long lab experience, original transcripts were reduced to contain only safety stories (i.e., stories told in response to practitioner and patient safety prompts). Stories told in response to prompts for other IOM quality aims (i.e., timely, equitable, effective, patient-centered) were purposefully excluded. The abbreviated transcript provided to students was 16 pages single-spaced and contained 14 patient safety stories and 11 practitioner safety stories. A copy of the transcript is purposefully excluded from this document in accordance with our confidentiality agreement with the hospital research sites.

Each lab assignment contained a template, which teams used to create the lab submission (Appendix C.5).

6.2.5.2 Stakeholder experts

Each stakeholder expert was provided access to an online project site hosted by Virginia Tech's course management system, which contained de-identified copies of the conceptual designs submitted by student design teams.

6.2.6 Procedure

6.2.6.1 Student designers

After informed consent was obtained, student participants completed a demographic questionnaire, which was used to assign students to four-person design teams. The study was incorporated into the course as a series of four labs, each exploring a different phase of the user-centered design process. As part of their coursework all students were tasked with analyzing ER nurses' stories to: (1) identify functional needs, (2) identify usability needs, (3) identify a design opportunity, and (4) create a conceptual design for the identified design opportunity. All labs were conducted within the normal 90-minute class period. All lab materials and assignments were distributed and collected using Virginia Tech's course management system. However, the primary researcher did not obtain access to course assignments until after the end of the semester in accordance with IRB guidelines.

Students in Section B were randomly chosen to receive lab instructions that incorporated the Storytelling + Design analysis methods (Appendix C). Students in Section A were provided with lab instructions that offered a traditional approach to user needs analysis. Sections 6.2.6.1.1 through 6.2.6.1.4 provide an overview of each lab exercise.

6.2.6.1.1 Lab 1: Introduction to user needs analysis

Following a 45-minute introduction to functional needs identification presented via PowerPoint, teams practiced identifying functional needs within the ER stories during the remainder of the class, which was approximately 45 minutes. The Lab 1 instructions for W teams (Appendix C) contained instructions for restructuring ER stories into narratives prior to

functional analysis, while WO teams were instructed to use the transcripts for functional analysis (Appendix C). During the in-class exercise, the primary investigator led the class through an example before students formed into teams to work on the Lab #1 assignment together. Students had two weeks to complete the first lab assignment.

6.2.6.1.2 Lab 2: Introduction to usability needs

The second course lab built upon the Lab 1 results as teams used the Lab 1 submission as the data source for Lab 2. Following a 30-minute course lecture on usability needs, students were provided instructions for the identification of usability needs within the Lab 1 submission. Similar to the Lab 1 instructions, WO teams identified usability needs from the transcript while W teams identified usability needs from the narratives previously created in Lab 1. The Lab 2 instructions also differed for W teams as students were tasked with identifying usability needs in a specific sequence (Appendix C). In addition, the W teams' instructions provided grammar rules for the specification of each type of usability need identified. In contrast, the instructions for WO teams (Appendix C) did not provide any constraints on the identification or specification of usability needs. However, each set of instructions provided detailed examples.

Similar to Lab 1, the primary investigator used part of the session to work an example together with the class. Design teams used the remaining class time to work on the Lab 2 assignment, which was due in 2 weeks.

6.2.6.1.3 Lab 3: Identifying a design opportunity

Following a brief PowerPoint presentation detailing the Lab 3 assignment, the majority of the 90-minute class period was used as an in-class exercise for students to discuss the findings of Labs 1 and 2. Students were tasked with the identification of a design opportunity informed by the functional and usability needs identified in previous labs. The overall purpose of this lab was for design teams to identify a problem informed by ER stories, which the teams would address in Lab 4. The Lab 3 instructions (Appendix C.5) for both class sections were the same since the design guidance within the Design + Storytelling framework culminated with the identification of user needs, which was completed in Lab 2. Each team submitted a rationale containing supporting evidence from the ER stories using the assignment template. Since students used the majority of class time to work collaboratively on Lab 3, students had one week to complete the assignment.

6.2.6.1.4 Lab 4: Creating a conceptual design

An overview of conceptual design components (e.g., storyboards, scenarios, design mock-ups) was presented to students during the first 45 minutes of the class period. Students used the remaining class period, approximately 45 minutes, to work on the Lab 4 assignment, which was due in two weeks.

6.2.6.2 Stakeholder experts

After informed consent was obtained via the online demographic questionnaire, experts were provided online access to a project site. The project site, hosted by Virginia Tech's course management system, contained de-identified copies of the eight conceptual designs submitted by student design teams. Course project folders were created to guide experts through the critique process (Appendix C.7). Experts first reviewed and critiqued each conceptual design individually (Appendix C.8). Conceptual designs were presented to each expert in a random order to control for potential ordering effects. Links to the online critique form were provided with each conceptual design.

Individual questionnaire items were informed by device standards and medical device literature. For example, usability question items were created to elicit expert reviews for the

effectiveness, efficiency, and overall satisfaction of the device since ANSI/AAMI HE75 (2009) and IEC 62366 (IEC, 2007) include these components within definitions for medical device usability. The functionality question items were created to consider not only the basic functionality of the proposed design, but experts' opinions regarding the perceived competitive advantage when released to market. For example, the question item, "The design is an elegant solution to the identified problem" was informed by references to functional elegance within medical device literature (Kossack, Gellatly, & Jandrisits, 2007) and reminders within standards to consider the design's appeal in the marketplace (ANSI/AAMI, 2009). Similarly, the question item, "The conceptual design represents an innovative design solution" was inspired by literature calling for innovative technological solutions within healthcare (Crocker & Timmons, 2009; Eskew, Jacobi, Buss, Warhurst, & DeBord, 2002; Greenberg & Buxton, 2008; Muto & Israelski, 2007; Shah, Robinson, & AlShawi, 2009).

After experts submitted critiques for all eight conceptual designs, experts accessed an online questionnaire, which prompted experts to rank each design in comparison with all other designs. In an effort to reduce hesitancy to provide negative reviews, stakeholder critiques were not shared with student design teams.

6.2.7 Analysis

The purpose of the third phase was to address RQ2, which investigates the impact of the framework on design. The framework's impact was conceptualized as the quality of the user need set and associated conceptual design created by teams that utilized the framework's instructions. RQ2a investigated the quality of the user need set, utilizing analyses methods previously employed in Phase 2 of the study. For example, the quality of the user need set was evaluated by each sets' breadth (i.e., coverage of needs' categories) and depth (i.e., quantity of needs' within each category). RQ2b investigated the quality of the conceptual designs, which were critiqued by stakeholder experts in terms of functionality, usability, and overall appropriateness within an ER setting. This section details the analyses for each of the Phase 3 research questions and associated hypotheses.

6.2.7.1 RQ2a: What is the impact of the framework's analysis instructions on designers' ability to identify user needs?

Teams' first two lab submissions formed the data set for RQ2a analyses. Each team's list of functional (i.e., Lab 1) and usability (i.e., Lab 2) needs were copied into an Excel spreadsheet for post-hoc analyses. Two teams were excluded from RQ2a analyses due to incomplete submissions for at least one of the lab assignments. Team W4 was excluded due to an incomplete submission of Lab 2, which contained a listing of participant quotes instead of usability needs. Team W3 was excluded for incomplete submissions of both Lab 1 and Lab 2. Teams were instructed to utilize Microsoft Word's commenting feature to highlight quotes that supported the identification of functional and usability needs listed. Team W3's submissions only contained listing of needs without any traceability to nurses' statements, resulting in the exclusion of Team W3 from RQ2 analyses. The exclusion of these two teams resulted in three sets representing user needs identified without framework instructions (e.g., WO1, WO2, WO3) and five sets representing user needs identified with the framework instructions (e.g., W1, W2, W4, W5, W6).

Prior to analyses, teams were assigned to "high experience" or "low experience" groups for design, requirements engineering, usability engineering, conceptual design creation, and healthcare experience (Table 50) since efforts to balance teams were not successful due to the relatively small number of participants within each class section. Groups were created based on a median split for the percent of students who reported experience per team. Overall, teams W2 and W4 reported the most previous experience.

Table 50. Experience levels per team based on median-split

| Team | Experience Level | | | | | |
|------------|------------------|-----------------------------|--------------------------|----------------------|------------|---------|
| | Design | Requirements Engineering | Usability Engineering | Conceptual Design | Healthcare | Overall |
| WO1 | Low | Low | Low | High | Low | Low |
| WO2 | Low | High | Low | High | Low | Low |
| WO3 | Low | Low | Low | Low | High | Low |
| W1 | Low | High | High | High | High | High |
| W2 | High | Low | Low | High | High | High |
| W4 | High | High | High | Low | High | High |
| W5 | Low | Low | Low | Low | High | Low |
| W6 | High | Low | Low | Low | High | Low |

Table 51 summarizes the hypotheses for RQ2a. Prior to analyses it was hypothesized that teams with the framework’s analysis instructions (i.e., W teams) would identify more user needs than teams without benefit of the framework (i.e., WO teams). No expected difference was expected in breadth of user needs identified by W and WO teams. It was also hypothesized that teams utilizing the framework instructions would create user need sets similar in composition to the “ideal” set identified in Phase 2.

Table 51. RQ2a hypotheses

| | Hypotheses | Planned Analyses | Actual Analyses |
|---------------------|--|---|--|
| RQ2a-1 (breadth) | No expected difference in the breadth of sets identified by WO and W teams | Two-sample t-test | Visual inspection of data distributions |
| RQ2a-1 (depth) | W teams will identify significantly more functional, usability, and context-of-use needs | Two-sample t-test | Visual inspection of data distributions |
| RQ2a-2 | No significant differences between W teams' sets and the ideal set | Visual inspection of Venn diagrams depicting the intersection of teams' sets with the ideal set | Visual inspection of the distribution of teams' sets compared with the ideal set |

Due to low recruitment of student design teams and the required exclusion of some teams due to incomplete submissions, the original analyses planned for RQ2a-1 were not appropriate. As the small data set and unbalanced groups prevented statistical tests, data distributions of the breadth and depth of sets were explored to identify potential trends in the data. Box plots were not used as the minimum number of observations required for boxplots (i.e. 5 observations) were not met.

In addition, planned analyses for RQ2a-2 were adapted due to an inability to reliably match individual needs identified by teams with specific needs within the ideal set. Attempts to reconcile results via a card sorting task between two independent sorters was unsuccessful (Appendix C), Cohen's $\kappa = 0.39$. In addition, reconciliation of user needs through traceability to specific quotations within the transcript was also unsuccessful as the majority of disputed needs could be traced back to similar (i.e., a quotation within the same story), but not exact quotations (i.e., the same line within the story).

Although the union of W teams' sets with the ideal was not successful, comparisons were still explored through investigations of set compositions. For example, the ratio of functional, usability, and context-of-use needs within W teams' sets were compared with the ideal to investigate if the set indicated the teams' focus on functional, usability, and/or context-of-use needs. Differences in emphasis on functional, usability, and/or context-of-use needs were discerned by the relative size of the circles within each diagram (Table 57). Differences in the dispersion (i.e., categorization of user needs as relating to functional, usability, and /or context-of-use) were identified by percent ratios of intersections to set unions. The relative size of the intersection of interest was deemed as either "small" or "large" based on a mean-split. For example, the intersection between functional and usability needs (i.e., needs which were categorized as both functional and usability) was found to be "large" for teams W5 and W6 as the percent ratio for these sets was greater than the mean across teams ($M = 0.17$, $SD = 0.12$).

As Phase 3 design teams only analyzed habitual safety stories elicited from Group GH, the "ideal" user need set was reduced to contain only needs identified within these particular stories. Venn diagrams were created using the Venn Diagram macro in version 9.0 of JMP statistical software.

6.2.7.2 RQ2b: What is the impact of the frameworks’ analysis instructions on designers’ ability to identify a design opportunity?

The purpose of RQ2b was to determine how the analysis instructions provided within the framework impacted designers’ ability to identify a design opportunity that addressed nurses’ needs. The stakeholder experts’ critiques were the data source for RQ2b. As all teams successfully submitted Lab 4, no teams were excluded from RQ2b analyses due to insufficient data. Although a total of ten designs were collected as part of this work, two of the W teams’ conceptual designs (i.e., W4, W6) were randomly excluded to: (1) reduce the workload of stakeholder experts who all volunteered time to critique projects without any compensation and (2) create an equal number of groups for post-hoc analyses of experts’ rankings.

Similar to RQ2a-1, teams were assigned to “high experience” or “low experience” groups for based on a median split of self-reported design experience (Table 52). These groupings were used to investigate potential effects of teams’ experience on rank scores.

Table 52. Design team experience levels for RQ2b analyses

| Team | Experience Level | | | | | |
|------------|------------------|--------------------------|-----------------------|-------------------|------------|---------|
| | Design | Requirements Engineering | Usability Engineering | Conceptual Design | Healthcare | Overall |
| WO1 | Low | Low | Low | High | Low | Low |
| WO2 | Low | High | Low | High | Low | Low |
| WO3 | Low | Low | Low | Low | High | Low |
| WO4 | High | Low | Low | Low | High | Low |
| W1 | Low | High | High | High | High | High |
| W2 | High | Low | Low | High | High | High |
| W3 | High | High | Low | Low | High | High |
| W5 | Low | Low | Low | Low | High | Low |

The hypothesis for RQ2b was that experts would rank W teams’ conceptual designs as better than WO teams’ designs (Table 53).

Table 53. RQ2b hypothesis and analysis approach

| Research Question | Hypothesis | Analysis |
|--------------------------|---|--|
| RQ2b | Teams with the framework analysis instructions (i.e., W teams) will receive significantly higher rankings than those without (i.e., WO teams) | Cochran Haenszel Mantel test for two-way non-parametric analysis of variance |

The distributions of teams' rankings were tested using the Shapiro-Wilk test with an alpha level of 0.05. As the distributions were non-parametric, differences were tested using the Cochran Haenszel Mantel test for a two-way non-parametric analysis of variance. Inter-rater reliability was not calculated as the Cochran Haenszel Mantel test controls for variability between raters.

In an effort to provide further insight into the RQ2b findings, post-hoc analyses were conducted for experts' questionnaire responses and written critiques. First, the survey items within the critique questionnaire were validated using item analysis; Chronbach alpha for functionality and usability items was 0.84 and 0.85, respectively. No question items were removed as the results indicated a higher Chronbach alpha with the inclusion of all questions. Normality of the question item data was testing using the Shapiro-Wilk test with an alpha level of 0.05. As all question items had non-parametric distributions, differences were tested using the Cochran Haenszel Mantel test for a two-way non-parametric analysis of variance.

Thematic analysis of experts' textual critiques provides further insight into experts' questionnaire responses and rankings (See Sections 6.3.1.2.2 and 6.3.1.2.3). Prior to thematic analysis, a coding scheme was created (Table 54). As the questionnaires were designed to elicit critiques of specific quality indicators (i.e., functionality, usability, overall appropriateness within and ER setting) of each conceptual design these categories were also included in the coding scheme.

Table 54. Coding scheme for thematic analysis of experts' textual critiques

| Coding category | Operational definition |
|---------------------------|--|
| User needs | |
| Quantity | Reference to the number of needs identified |
| Specification | Reference to how needs are specified (i.e., clear, consistent, etc....) |
| Conceptual Design | |
| Functionality | Critique for “what” the conceptual design does |
| Usability | Critique for “how” the conceptual design does it |
| ER appropriateness | Critique of the match / mismatch between the conceptual design and the users, tasks, and working context within an ER / hospital setting |
| Design elegance | References to the simplicity / complexity of the design |

Additional categories were added to the coding scheme to provide further insight into the RQ2a and RQ2b findings presented in Sections 6.3.1.1 through 6.3.1.2.1. Specification of user needs was included due to inconsistencies found in specifications during investigation of RQ2a-2 (See Section 6.3.1.1.2). As differences in user needs identified were found between groups (See Section 6.3.1.1.1), the quantity of user needs was also added as a coding category to provide further insight into the association between the quantity of needs identified and experts' critiques. Elegance was also included due to the trend for experts to view W teams' designs as more elegant than WO teams' designs (See Section 6.3.1.2.2).

Two independent coders categorized experts' statements using the pre-determined coding scheme (Table 54). The primary researcher and an electrical engineering graduate with 12 years of experience creating design specifications and writing government standards acted as coders. Coders used a Microsoft Excel spreadsheet to group sentences within stakeholder responses to one of the coding scheme categories. The inter-rater reliability was calculated using Cohen's κ . The coding scheme was deemed acceptable as inter-rater reliability indicated acceptable agreement between coders with Cohen's $\kappa = 0.79$.

6.3 Results

Student teams created ten conceptual designs as a result of Phase 3 (Table 55). Although all designs were informed by the same ER nurses' stories relating to patient and staff safety, the design teams focused on different aspects of safety within the designs. Four teams (i.e., WO1, WO2, WO4, W2) focused efforts on safer medication delivery and three teams (i.e., W4, W5, W6) designed systems to improve access to medical records. Team W1 designed to improve overall hospital security and Team WO3 designed a hospital bed to reduce injuries to patients due to falls. Team W3 created a decision aid system to help nurses correctly identify patients' rooms.

Teams WO4 and W3 were excluded from RQ2a due to incomplete submissions of the Lab 1 and / or Lab 2 assignments. Sections 6.3.1.1.1 and 6.3.1.1.2 detail the findings for the remaining three WO and five W design teams. Results for RQ2 are provided in Section 7.3.1.

Table 55. Students' conceptual designs in Phase 3

| Team | Conceptual Design Title | Identified Design Opportunity Description |
|------|-------------------------|---|
| WO1 | Dosage Calculations | Miscalculating dosages of medication is a problem in hospitals, not only in the hospital that the researcher studied, but we researched online and found it to be an issue with others as well. |
| WO2 | Dosage Calculations | The problem to address is to find a better way to calculate the dosage needed for each patient. |
| WO3 | Hospital Bed | We decided to redesign a hospital bed to address the problems that both the staff and the patients face on a daily basis...: patient restriction, risk, comfort, identification, and staff safety. |
| WO4* | Med Wand | In normal and especially stressful situations, ER nurses have historically mixed up which drugs are distributed to which patient. |
| W1 | Security | We intend to address the problem of security. |
| W2 | RFID wristband | We see an opportunity to implement a system that double checks nurses' quantities or types of substances given to patients within the ER. |
| W3* | Reduce Nurse Confusion | To create less confusion for nurses in rushed situations. |
| W4+ | Tablet Medical Records | To ensure that patients receive appropriate and timely care, a system must be implemented to provide doctors and nurses pertinent medical information about their patients in a way that avoids confusion and reduces error. |
| W5 | Patient Information | Our group identified an opportunity to provide nurses with additional patient information...: a patient's allergies and history, location, mental condition, insurance situation, blood type and others. |
| W6+ | Staff Communication | Communication is an issue that affects numerous departments in the hospital. Through this system, the patient information will be displayed between the nurses', the charge nurse, EMT, and the security departments of the hospital. |

*excluded from RQ2a analyses, +excluded from RQ2b analyses

6.3.1 RQ2: What is the impact of the framework's analysis guidance on design?

6.3.1.1 RQ2a: What is the impact of the framework's analysis instructions on designers' ability to identify user needs?

6.3.1.1.1 RQ2a-1: How are the user need sets identified by designers provided with analysis instructions (i.e., W teams) different than sets identified without instructions (i.e., WO teams)?

Visual inspection of the data distributions for the breadth of user needs identified suggests reveals no differences between WO ($M = 11.3$, $SD = 1.2$) and W teams ($M = 11.4$, $SD = 0.6$), See Figure 85.

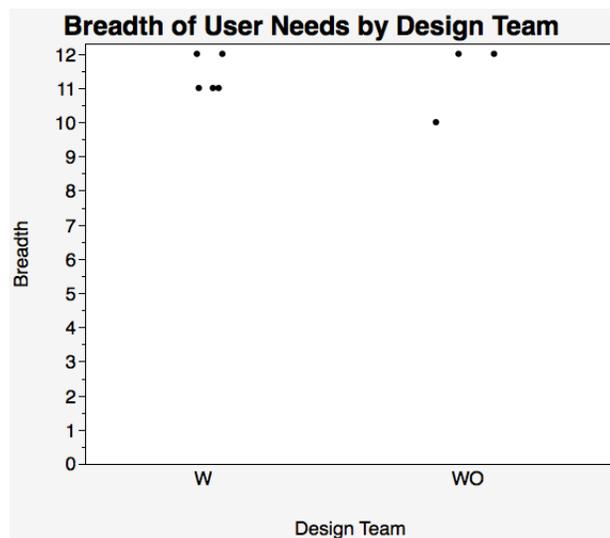


Figure 85. Distribution of breadth of user need sets for WO and W teams

Overall, the quantity of total user needs identified varied greatly between groups (min = 103, max = 203); Team W2 identified the least amount of total needs and Team W4 identified the most (Figure 86). Surprisingly, two of the three teams with the lowest quantity of needs identified (i.e., W1, W2) were teams using the framework's analysis instructions.

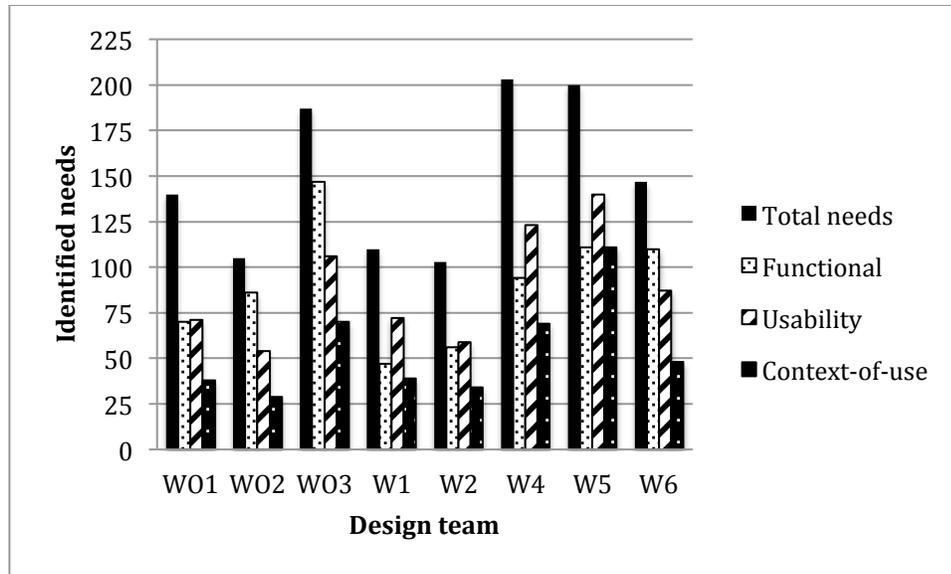


Figure 86. User needs identified per design team

In terms of functionality, teams identified a range of 47 to 147 functional needs from the ER nurses’ stories. In addition to identifying the least amount of total needs, Team W2 also identified the smallest quantity of functional needs in comparison to other groups. Again, the results were surprising in the respect that the two teams with the lowest number of identified functional needs (i.e., W1, W2) were groups that worked with the framework’s analysis instructions.

However, Figure 86 suggests an advantage for W teams in the identification of usability needs as five of the six W teams identified more usability needs than WO teams. Overall, the quantity of usability needs identified ranged from 54 to 140. Team WO2 identified the least quantity while Team W5 identified the greatest quantity of usability needs.

Figure 86 also suggests a potential difference in focus between the two groups. Group WO teams all identified more functional needs than usability needs, whereas Group W teams all identified more usability needs than functional needs. This suggests a potential difference in teams’ focus during user need identification where Group W teams appeared to focus on functionality and Group WO teams appeared to focus on usability. These potential differences in focus are explored further in RQ2a-2, in which Venn diagrams representing the characteristics of each user need set is compared to the ideal set identified by qualitative analysts in Phase 2.

Since all WO teams were “low overall experience” teams based on self-reported demographic data (See Tables 48 and 50), potential differences in the quantities of total,

functional, usability, and context-of-use needs due to group experience level were investigated first (Table 56).

Table 56. Mean needs identified per group experience level

| Experience type | Experience level | N | Total needs Mean (SD) | Functional Mean (SD) | Usability Mean (SD) | Context-of-use Mean (SD) |
|-------------------|------------------|---|--------------------------|-------------------------|------------------------|-----------------------------|
| Design | High | 3 | 151.0 (50.1) | 86.7 (27.7) | 89.7 (32.1) | 50.3 (17.6) |
| | Low | 5 | 148.4 (43.5) | 92.2 (38.5) | 88.6 (34.4) | 57.4 (33.7) |
| Requirements | High | 3 | 139.3 (55.2) | 75.6 (25.2) | 83.0 (35.8) | 45.7 (20.9) |
| Engineering | Low | 5 | 155.4 (38.9) | 98.8 (36.3) | 92.6 (31.8) | 60.2 (31.6) |
| Usability | High | 2 | 156.5 (65.8) | 70.5 (33.3) | 97.5 (36.1) | 54.0 (21.2) |
| Engineering | Low | 6 | 147.0 (40.4) | 96.7 (32.9) | 86.2 (32.5) | 55.0 (31.1) |
| Conceptual Design | High | 4 | 114.5 (17.3) | 64.8 (17.1) | 64.0 (8.9) | 35.0 (4.6) |
| Creation | Low | 4 | 184.3 (25.8) | 115.5 (22.4) | 114.0 (22.7) | 74.5 (26.4) |
| Healthcare | High | 6 | 158.3 (44.9) | 94.2 (37.4) | 97.8 (30.9) | 61.8 (28.4) |
| | Low | 2 | 122.5 (24.8) | 78.0 (11.3) | 62.5 (12.0) | 33.5 (6.4) |
| Overall | High | 3 | 138.7 (55.8) | 65.7 (25.0) | 84.7 (33.2) | 47.3 (32.7) |
| | Low | 5 | 155.8 (38.1) | 104.8 (29.2) | 91.6 (33.2) | 59.2 (32.7) |

Visual inspection of the distributions for functional, usability, context-of-use, and total needs suggests that teams' previous experience creating a conceptual design affected the quantity of needs identified. Teams with low conceptual design experience ($M = 184.3$, $SD = 25.8$) tended to identify more needs in all categories (i.e., functional, usability, context-of-use) than groups with high conceptual design experience ($M = 114.5$, $SD = 17.3$) (Figure 87). One potential explanation is that teams with limited experience creating conceptual designs (i.e., WO3, W4, W5, W6) may have been motivated to identify more needs in an effort to ensure a higher assignment grade for an unfamiliar task.

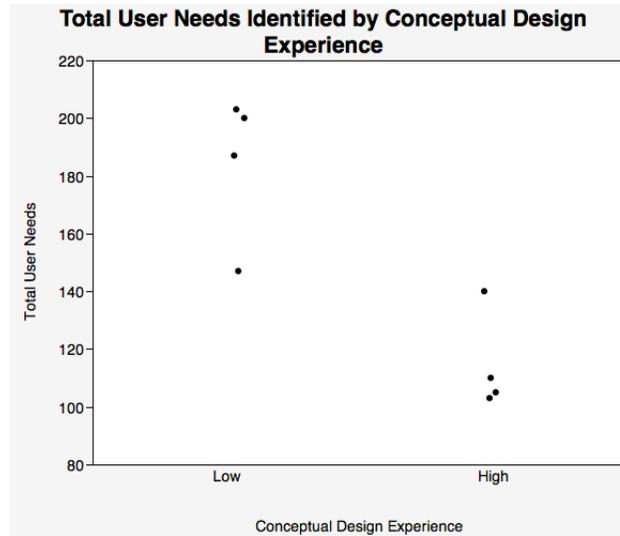


Figure 87. Trend for differences in quantity of total user needs identified between teams grouped by conceptual design experience level

Visual inspection of the data reveals a trend for students with less conceptual design experience to identify more functional needs ($M = 115.5, SD = 22.4$) than students with greater experience creating conceptual designs ($M = 94.2, SD = 37.4$), See Figure 88.

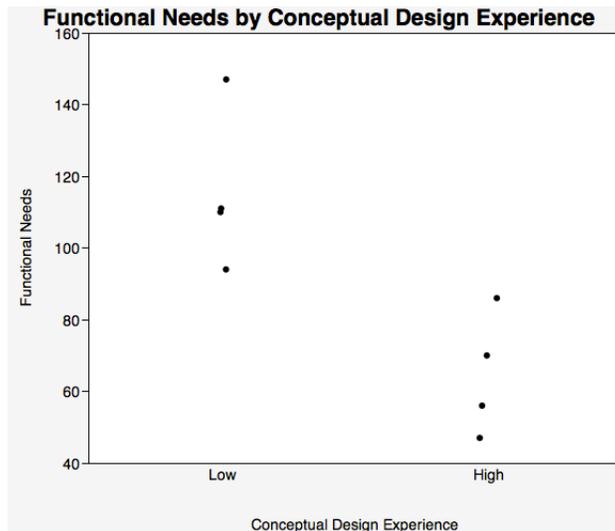


Figure 88. Trend for differences in quantity of functional needs identified by teams of low/high experience

The trend is also evident for the quantity of user needs identified. In addition, low experience teams had greater variation in the number of usability needs identified ($M = 114.0, SD = 22.7$) than high experience teams ($M = 64.0, SD = 8.9$), See Figure 89.

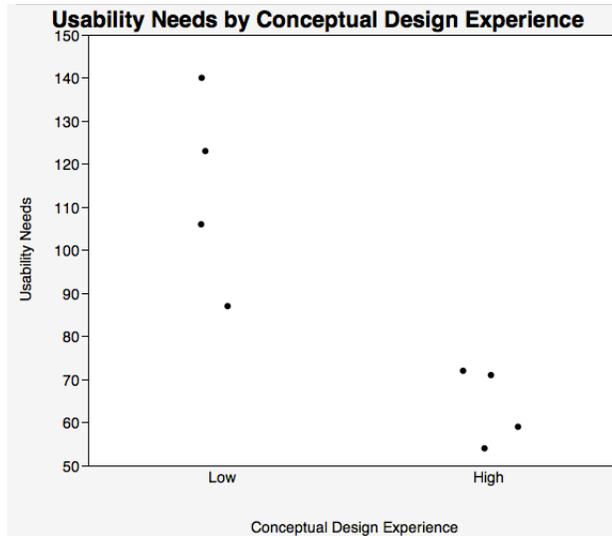


Figure 89. Trend for differences in quantity of usability needs identified by teams of low/high experience

The variation in the quantity of user needs identified by high experience teams ($M = 35.0$, $SD = 4.6$) was less than those identified by low experience teams ($M = 74.5$, $SD = 26.4$, See Figure 90).

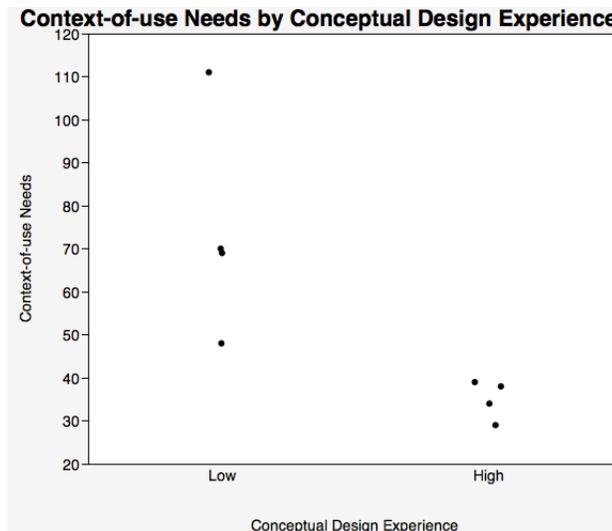


Figure 90. Trend for differences in the quantity of context-of-use needs identified by teams of low/high experience

Although Figure 86 suggests a difference in focus between WO and W teams, visual inspection of the data distributions did not reveal any differences for the quantity of total, functional, usability, or context-of-use needs identified by WO and W teams (Table 57). Data distributions for all visual inspections relating to RQ2a-1 are provided in Appendix C.10.

Table 57. Quantity of needs identified by WO and W teams

| Group | Total needs | Functional needs | Usability needs | Context-of-use |
|--------------|--------------------|-------------------------|------------------------|-----------------------|
| | Mean (SD) | Mean (SD) | Mean (SD) | Mean (SD) |
| WO | 144.0 (41.2) | 101.0 (40.6) | 77.0 (26.5) | 45.7 (21.5) |
| W | 152.6 (47.7) | 83.6 (30.2) | 96.2 (34.2) | 60.2 (31.4) |

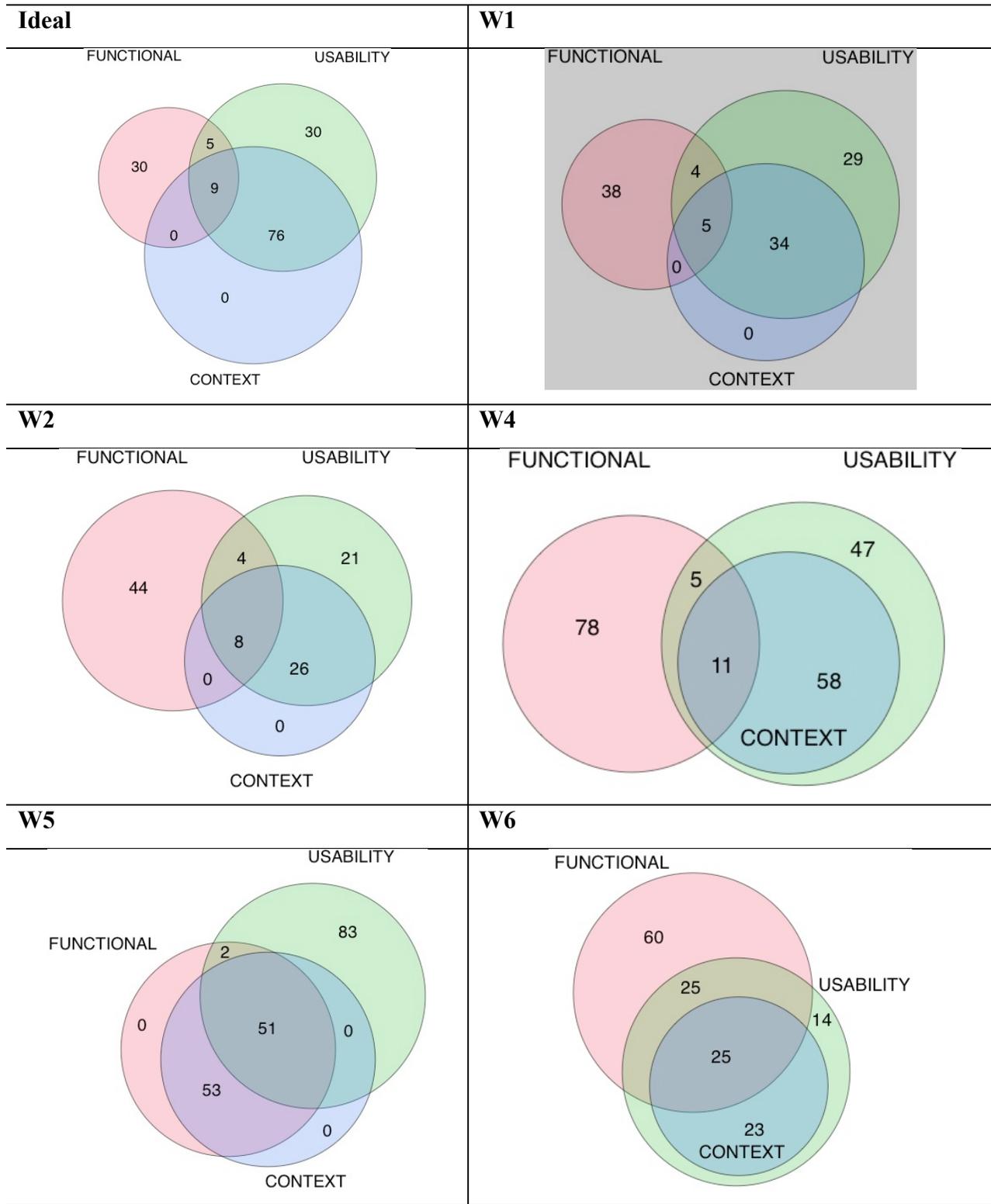
Although no differences in the quantity of user needs between WO and W teams were found, previous analyses revealed that contextual design experience was found to be associated with a greater quantity of user needs. Section 6.3.1.1.2 details the RQ2a-2 results, which explore composition differences between the W teams' sets and the ideal set.

6.3.1.1.2 RQ2a-2: How are the user need sets identified by designers using the framework's analysis instructions (i.e., W teams) different than the set identified by qualitative analysts?

Visual inspection of the Venn diagrams for W teams' user needs indicated differences in the emphasis and dispersion of user needs identified between teams (Table 58).

Table 58. Comparisons of W teams' sets with the ideal set identified by qualitative analysts

Compositions of User Needs Sets



The sets created by teams W1, W2, and W4 were similar in dispersion characteristics to the ideal (Table 59). These sets tended to have small overlap between functionality and usability needs, which indicates an understanding of the difference between the two types of needs. This finding also suggests that these teams utilized the framework's specification instructions in a manner similar to the qualitative analysts, which provides confirmation that the instructions were used successfully during a design task. In addition, these sets tended to have a large overlap of usability and context-of-use needs, which was expected considering the context-of-use needs were defined as a subset of usability needs in the specification grammar.

Table 59. Comparison of set characteristics of W teams' user needs sets with the ideal

| Set | Emphasis | Dispersion | | |
|--------------|--|-------------------|---------------|---------------|
| | | Intersection | Percent ratio | Relative size |
| Ideal | Context > Usability > Functional | $F \cap U$ | 0.09 | Small |
| | | $F \cap C$ | 0.08 | Small |
| | | $F \cap U \cap C$ | 0.06 | Small |
| | | $U \cap C$ | 0.71 | Large |
| W1 | Usability > Context > Functional | $F \cap U$ | 0.08 | Small |
| | | $F \cap C$ | 0.06 | Small |
| | | $F \cap U \cap C$ | 0.05 | Small |
| | | $U \cap C$ | 0.54 | Large |
| W2 | (Functional \approx Usability) > Context | $F \cap U$ | 0.11 | Small |
| | | $F \cap C$ | 0.10 | Small |
| | | $F \cap U \cap C$ | 0.07 | Small |
| | | $U \cap C$ | 0.58 | Large |
| W4 | (Functional \approx Usability) > Context | $F \cap U$ | 0.08 | Small |
| | | $F \cap C$ | 0.07 | Small |
| | | $F \cap U \cap C$ | 0.06 | Small |
| | | $U \cap C$ | 0.57 | Large |
| W5 | (Usability \approx Functional \approx Context) | $F \cap U$ | 0.28 | Large |
| | | $F \cap C$ | 0.98 | Large |
| | | $F \cap U \cap C$ | 0.27 | Large |
| | | $U \cap C$ | 0.27 | Small |
| W6 | (Functional \approx Usability) > Context | $F \cap U$ | 0.34 | Large |
| | | $F \cap C$ | 0.18 | Small |
| | | $F \cap U \cap C$ | 0.17 | Large |
| | | $U \cap C$ | 0.55 | Large |

The user needs sets submitted by teams W5 and W6 differed from the ideal in terms of dispersion. Both teams had a relatively large overlap in functional and usability needs, which suggests confusion between specification of “what” the solution should do and “how” the design should accomplish the intended function. In contrast with the ideal set, both teams tended to categorize user needs within all three categories (i.e., functional, usability and context-of-use) than what was expected. Again, this suggests general confusion among Team W5 and W6 members regarding the distinction between needs, which may suggest the definitions within the framework’s specification instructions are unclear.

Visual inspection of the Venn diagrams also revealed differences in teams’ emphasis on certain categories of user needs. The ideal set emphasized usability over functional needs, but the majority of usability needs identified were context-of-use. Of the teams that utilized the framework’s analysis instructions, Team W1’s set most closely matched the ideal set in terms of emphasis. Similar to the ideal, Team W1 emphasized usability over context. However, context-of-use needs were not the primary usability needs identified by the team, which indicates the team emphasized other usability categories (e.g., efficiency, effectiveness, satisfaction) over context-of-use.

In contrast to the ideal set’s emphasis on context-of-use needs, teams W2, W4, and W6 all emphasized functionality and usability needs equally over context-of-use needs. Since Team W5 tended to categorize needs within all three categories simultaneously, the team tended to place equal emphasis on usability, functional, and context-of-use needs.

6.3.1.1.3 Summary of findings RQ2a

Table 60. Summary of findings for RQ2a

| RQ | Hypotheses | Finding |
|---------------------|----------------------|--|
| RQ2a-1 (Breadth) | Supported | No identified trends for differences in the breadth of sets identified by WO and W teams |
| RQ2a-1 (depth) | Not Supported | No identified trends for differences in the depth of functional, usability, or context-of-use needs identified by WO and W teams |
| RQ2a-2 | Not Supported | No W set matched the ideal set in terms of dispersion or emphasis |

6.3.1.2 RQ2b: What is the impact of the framework’s analysis instructions on designers’ ability to identify a design opportunity?

Teams’ ability to identify a design opportunity was determined by critiques of conceptual design submissions by expert reviewers. Experts provided feedback in form of survey responses and project rankings (i.e., 1 = best design, 8 = worst design) supported by textual explanations of each critique. Sections 6.3.1.2.1 through 6.3.1.2.4 present the results for RQ2b.

6.3.1.2.1 Conceptual design rankings

Team W2 ($M = 2.0$, $SD = 2.7$) received the best average ranking for functionality and Team WO3 received the worst average ranking ($M = 6.3$, $SD = 0.6$), See Figure 91. Functionality rankings for Teams W1 ($M = 4.0$, $SD = 3.6$, min = 1, max = 8) and WO1 ($M = 4.3$, $SD = 3.6$, min = 1, max = 8) varied between experts, suggesting disagreements among expert raters for these two conceptual designs.

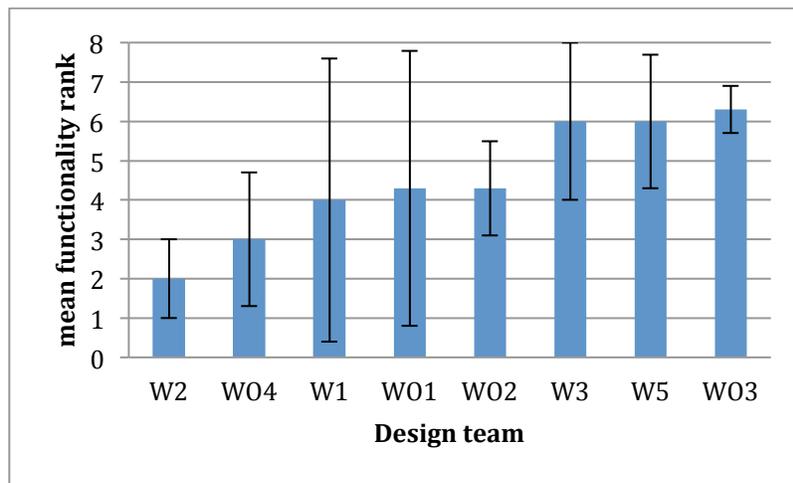


Figure 91. Mean functionality rankings per design team

Team WO3 also received the worst average usability ranking ($M = 7.3$, $SD = 6.7$) in comparison to other teams (Figure 92). Three of the top four ranked usability teams utilized the framework’s instructions.

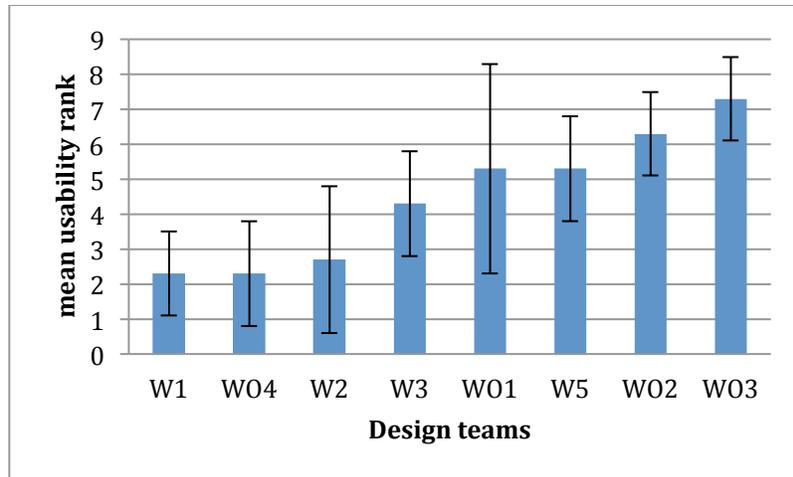


Figure 92. Mean usability ranks per design team

In overall rankings, three of the four top ranked conceptual designs were also from W teams. Surprisingly, the average overall ranking for team W5 ($M = 3.7$, $SD = 3.5$) was greater than the team's rankings for both functionality ($M = 6$, $SD = 1.7$) and usability ($M = 5.3$, $SD = 1.5$). Experts' rationales for rankings are explored further through a textual analysis of free-response critiques in Section 6.3.1.2.3.

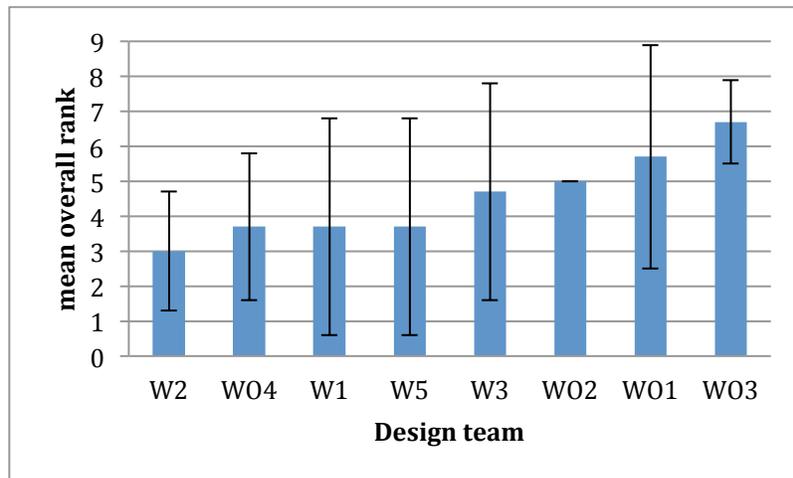


Figure 93. Mean overall ranks per design team

Similar to RQ2a-1 findings, significant differences were found between groups of different experience levels (See Table 61 and Table 62). Teams with more experience creating conceptual designs (e.g., WO, WO2, W1, W2) received better overall rankings ($M = 3.5$, $SD = 2.1$) than teams with limited conceptual design experience ($M = 5.5$, $SD = 2.2$), $\chi^2(1,24) = -4.00$, $p = .05$.

Table 61. Differences in conceptual design rankings between low/high experience teams

| Rank | Team Experience | | | | | | | | |
|----------------------|-----------------|-----------|----------------|-------------------|-----------|-------------------|--------------------|-----------|----------------|
| | Design | | | Conceptual Design | | | Overall Experience | | |
| | Low | High | | Low | High | | Low | High | |
| | Mean (SD) | Mean (SD) | $\chi^2(1,24)$ | Mean (SD) | Mean (SD) | $\chi^2(1,24)$ | Mean (SD) | Mean (SD) | $\chi^2(1,24)$ |
| <i>p</i> | | | <i>p</i> | | | <i>p</i> | | | |
| Overall | 5.3 (2.3) | 3.1 (1.8) | 4.63 | 5.5 (2.2) | 3.5 (2.1) | 4.00 | 5.2 (2.4) | 3.8 (2.2) | 1.78 |
| | | | .03* | | | .05 ⁺⁺ | | | .18 |
| Functionality | 4.4 (2.4) | 4.7 (2.4) | 0.07 | 5.4 (2.1) | 3.6 (2.3) | 3.36 | 4.9 (2.4) | 4.1 (2.3) | 0.70 |
| | | | .80 | | | .07 ⁺⁺ | | | .41 |
| Usability | 4.7 (2.5) | 4.2 (2.3) | 0.19 | 5.3 (2.1) | 3.7 (2.4) | 2.79 | 5.0 (2.4) | 4.0 (2.4) | 1.00 |
| | | | .67 | | | .10 ⁺⁺ | | | .32 |

* $p < .05$; ++ approached significance; Rankings 1 = highest, 8 = lowest

Table 62. Differences in conceptual design rankings between low/high experience teams

| Rank | Team Experience | | | | | | | | |
|----------------------|--------------------------|-----------|----------------|-----------------------|-----------|----------------|------------|-----------|--------------------|
| | Requirements Engineering | | | Usability Engineering | | | Healthcare | | |
| | Low | High | $\chi^2(1,24)$ | Low | High | $\chi^2(1,24)$ | Low | High | $\chi^2(1,24)$ |
| | Mean (SD) | Mean (SD) | | Mean (SD) | Mean (SD) | | Mean (SD) | Mean (SD) | |
| <i>p</i> | | | <i>p</i> | | | <i>p</i> | | | |
| Overall | 4.5 (2.4) | 4.5 (2.4) | 0.0 | 4.4 (2.5) | 5.3 (1.5) | 0.40 | 3.8 (2.3) | 4.7 (2.4) | 0.59 |
| | | | 1.0 | | | .53 | | | .44 |
| Functionality | 4.8 (2.3) | 3.7 (2.4) | 0.93 | 4.4 (2.4) | 5.0 (2.7) | 0.14 | 2.7 (2.0) | 5.2 (2.2) | 4.48 |
| | | | 0.34 | | | .71 | | | .03* |
| Usability | 4.8 (2.3) | 3.7 (2.5) | 0.93 | 4.5 (2.4) | 4.7 (2.1) | 0.02 | 3.0 (2.4) | 2.0 (2.2) | 3.00 ⁺⁺ |
| | | | .34 | | | .90 | | | .08 ⁺⁺ |

* $p < .05$; ++ approached significance; Rankings 1 = highest, 8 = lowest

Tests for differences in functionality and usability ranks based on conceptual design experience approached significance $\chi^2(1,24) = 3.36, p = .07$ and $\chi^2(1,24) = 2.79, p = .10$, respectively. Visual inspection of the distribution for functionality rank scores revealed a trend for groups with greater conceptual design experience to receive better functionality rankings ($M = 3.6, SD = 2.3$) than teams with less experience ($M = 5.4, SD = 2.1$), See Figure 94.

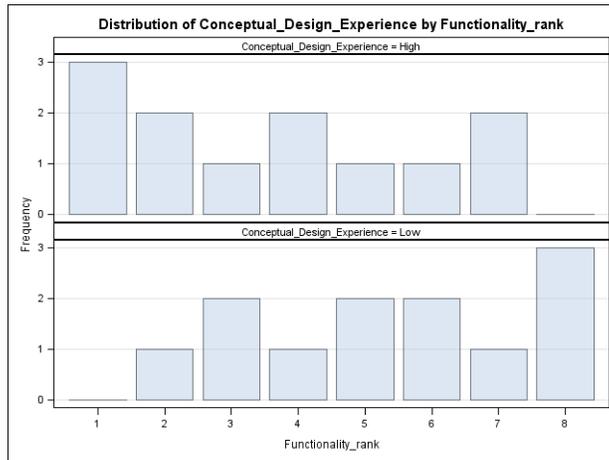


Figure 94. Distribution of functionality ranks scores by conceptual design experience

In addition, the distribution of usability ranks scores revealed a similar trend in which teams with greater conceptual design experience received better usability rankings ($M = 3.7, SD = 2.4$) than teams with less conceptual design experience ($M = 5.3, SD = 2.1$), See Figure 95.

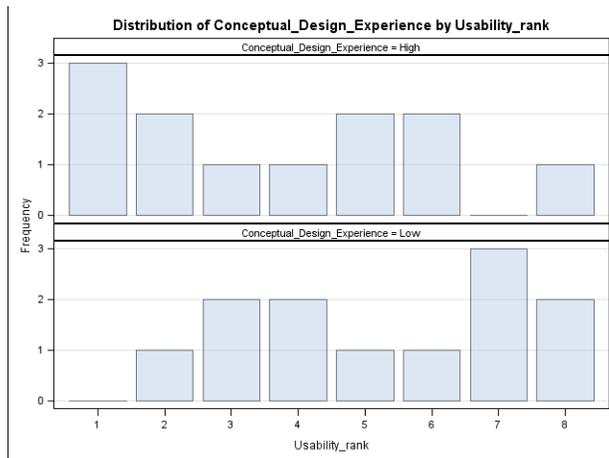


Figure 95. Distribution of usability ranks by conceptual design experience

Teams composed of more members with experience in healthcare and design also received significantly higher rankings (See Table 61 and Table 62). Teams with more design experience (i.e., WO4, W2, W3) received higher overall rank scores ($M = 3.1, SD = 1.8$) than teams with less design experience ($M = 5.3, SD = 2.3$), $\chi^2(1,24) = 4.63, p = .03$. Surprisingly, teams with

less experience working in healthcare (i.e., WO1, WO2) received significantly better functionality ranks ($M = 2.7$, $SD = 2.0$) than teams comprised of more members with healthcare experience ($M = 5.2$, $SD = 2.2$), $\chi^2(1,24) = 4.48$, $p = .03$.

Comparisons in conceptual design rankings between teams working with the framework's analysis instructions (i.e., W teams) and teams without (i.e., WO teams) suggest a trend for instructions to partially compensate for teams' experience level (Table 63). Comparison in usability ranks between WO and W teams approached significance, even though each grouping contained the same quantity of high and low conceptual design experience teams, $\chi^2(1,24) = 2.78$, $p = .10$.

Table 63. Mean conceptual design rankings for WO and W teams

| Rank | WO Teams | W Teams | $\chi^2(1, 24)$ | P value |
|----------------------|-----------|-----------|-----------------|--------------------|
| | Mean (SD) | Mean (SD) | | |
| Overall | 5.3 (2.1) | 3.8 (2.5) | 2.25 | 0.13 |
| Functionality | 4.5 (2.2) | 4.5 (2.6) | 0.0 | 1.0 |
| Usability | 5.3 (2.5) | 3.7 (2.5) | 2.78 | 0.10 ⁺⁺ |

$p < .05$; ++approached significance; Rankings 1 = highest, 8 = lowest

Visual inspection of the distribution of usability ranks suggests W teams ($M = 3.7$, $SD = 2.5$) received better usability rankings than WO teams ($M = 5.3$, $SD = 2.5$), See Figure 96.

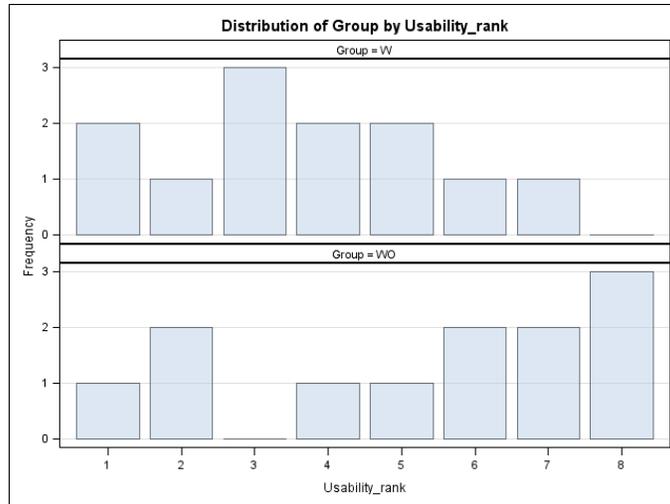


Figure 96. Distribution of usability ranks for W and WO teams

6.3.1.2.2 Questionnaire responses

No significant differences for experts' questionnaire responses were found between WO and W teams (Table 64). However, ratings for the functionality statement "The design is an elegant solution to the identified problem" approached significance, $\chi^2(1,24) = 2.86, p = .10$. Visual inspection of the distribution of responses suggests that experts agreed with this statement for Team W conceptual designs ($M = 3.4, SD = 0.9$) more often than for Team WO's conceptual designs ($M = 2.6, SD = 1.3$). See Figure 97.

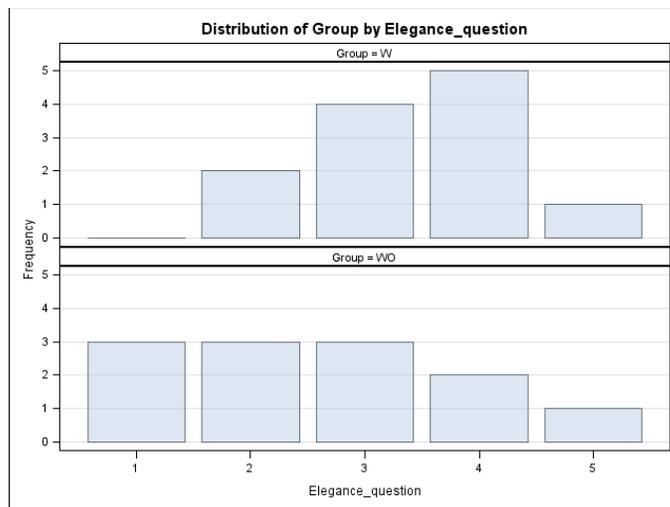


Figure 97. Distribution of expert responses for "elegance" questionnaire item

Table 64. Experts' questionnaire responses for the perceived functionality and usability of teams' conceptual designs

| Question | WO Teams | W Teams | $\chi^2(1, 24)$ | P value |
|---|-----------|-----------|-----------------|-------------------|
| | Mean (SD) | Mean (SD) | | |
| Functionality | | | | |
| The design addresses the identified functional needs. | 3.5 (1.5) | 3.5 (0.9) | 0.13 | .73 |
| The design does address a “real world” need within an ER setting. | 2.3 (1.0) | 2.4 (1.2) | 0.01 | .93 |
| The design is an elegant solution to the identified problem. | 2.6 (1.3) | 3.4 (0.9) | 2.86 | .10 ⁺⁺ |
| The conceptual design represents an innovative design solution. | 2.6 (1.3) | 3.3 (1.1) | 2.82 | .10 ⁺⁺ |
| Usability | | | | |
| The design addresses the identified usability need(s). | 3.1 (1.0) | 2.8 (0.8) | 0.30 | .58 |
| Some of the design’s intended users would find it difficult to use. | 2.8 (1.3) | 2.8 (1.1) | 0.01 | .93 |
| Users would prefer this design to what is currently available. | 2.8 (1.1) | 3.4 (0.9) | 2.0 | .16 |
| The design prevents users from making mistakes. | 3.2 (1.2) | 3.2 (1.3) | 0.01 | .93 |
| Users would be able to use this design quickly. | 2.6 (1.0) | 2.3 (0.8) | 0.20 | .66 |
| This design does not require a lot of the user’s resources to operate. | 2.5 (0.9) | 3.3 (0.8) | 1.12 | .29 |
| Context-of-use | | | | |
| The conceptual design is appropriate for use within an emergency room setting | 2.8 (1.2) | 2.6 (1.1) | 0.07 | .79 |

++ approached significance with alpha = .05; Means based on a 5-point likert scale where 1= strongly disagree, 5 = strongly agree

Comparisons between experts' responses for the innovativeness of the designs created by WO and W teams approached significance, $\chi^2(1,24) = 2.82, p = .10$. Visual inspection of the distribution of responses for the statement, "The conceptual design represents an innovative design solution." suggests that experts tended to view designs created by W teams ($M = 2.6, SD = 1.1$) as more innovative than those created by WO teams ($M = 3.3, SD = 1.1$).

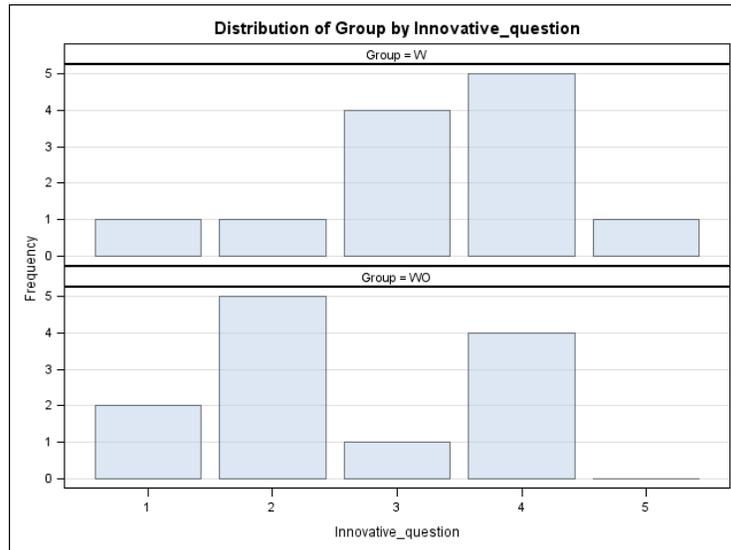


Figure 98. Distribution of expert responses for "innovative" questionnaire item

6.3.1.2.3 Textual critiques

A brief overview of experts' positive and negative statements regarding teams' identified user needs and conceptual designs are provided in Table 65 through Table 67; a full listing is provided in Appendix C. As the purpose of the tables is to highlight key issues, only one positive and negative statement is included per category per team regardless of how many experts commented on that issue. For example, multiple experts deemed the specification of Team WO2's user needs list as "vague" (Table 65). The tables also highlight disagreements between experts. For example, experts disagreed on the appropriateness of Team W1's design within an emergency room context (Table 66).

Experts' comments indicated that teams WO1, WO4 and W1 included an excessive number of functional needs than was what was appropriate for the intended conceptual design (Table 65). One reviewer noted that Team W1's functional list "masks a bit the true focus of the solution." However, a large quantity of needs was not negatively critiqued when the list was appropriate for the intended design. For example, an expert noted that although the quantity of

Team W5's functional needs list was "daunting" it was a "reasonable list". Experts did not provide any comments pertaining to the quantity of usability lists submitted by each team.

Experts often cited problems with the specification of the user needs list (Table 65). Expert comments indicated specification issues for all WO teams and 50% of W teams (i.e., W2, W3). Only team W2 was praised for submitting a "strong set of functional requirements", which reinforced the team's high functionality ranking (See Section 6.3.1.2.1). In contrast, Team W3's functional list was described as "vague", which suggests an unexpected discrepancy in the method used by each team considering both teams were expected to adhere to the framework's specification grammar.

The usability specifications for both WO and W teams were found lacking by experts. Teams WO3 and W3 were cited for not clearly separating functional and usability needs. Team WO1's usability list was critiqued as "poorly defined" and one expert noted that Team W2 needed "better usability goals". Experts also noted general problems with the specification. For example, one expert described the criteria used by Team WO3 to form user needs as "sloppy" since the list contained ambiguous and seemingly redundant needs. Experts did not provide any positive or negative comments regarding the specification submitted by Teams W1 and W2.

Table 65. Highlighted statements from experts' critiques of teams' user needs

| Team | Critique of User Needs | |
|------------|--|--|
| | Quantity | Specification |
| WO1 | Overstated or incorrectly stated functional needs. | The [usability] list was poorly defined. |
| WO2 | | The design specified is vague. |
| WO3 | | Usability needs aren't clearly any different than the functional needs. |
| WO4 | A targeted scope and limited functional needs...allows a reviewer (and I like to think a team) to focus on the actual issue. | Criteria themselves were sloppy. |
| W1 | The long list of functional needs masks a bit the true focus of the solution. | |
| W2 | | Strong set of functional requirements. Better usability goals are needed. |
| W3 | | The usability needs specified...seem to be some type of functional need or higher level goal. Better specifying the problem and functional needs could have helped drive a better solution. |
| W5 | Although the list of functional needs appeared daunting, I thought it was a reasonable list. | |

Expert critiques of conceptual designs elucidate differences in the quality of submissions between WO teams (Table 66) and W teams (Table 67) as many comments pertained to the proposed design solution's usability and appropriateness within an ER setting. Despite the identified problems with the functional needs list (Table 65), experts did not provide many comments regarding the functionality of the system. Team WO2 was praised for enhancing current hospital systems, while Team W3 was criticized for neglecting to consider potential security issues with the proposed computer system.

Experts' comments support the identified trend for W teams to receive higher usability rankings than WO teams (See Section 6.3.1.2.1). All WO teams were cited for usability problems within the proposed design. Team WO1's usability was described as "suspect" and Team WO2 and Team WO3's designs did not provide adequate protection against errors. One expert noted that the evaluation of Team WO4's usability was a "moot point" considering the design did not adequately address the functional needs. One of the W teams was critiqued for usability issues as well; Team W1's proposed interaction design was described as "cumbersome and inefficient". In contrast, only one team was praised for usability. Team W2's design was described as "a good user experience for all", which supports its relatively high usability ranking in comparison to other teams (Figure 92). Experts did not provide any additional positive or negative comments explaining the usability critiques for Teams W2 and W5.

Analysis of experts' comments suggests that the overall appropriateness of designs within an ER setting was difficult to gauge, which may explain the average rating of "neutral" in response to the question, "The conceptual design is appropriate for use within an emergency room setting" (Table 64). Different experts rated the designs created by Teams WO1, WO2, WO4 and W1 as both appropriate and inappropriate. However, the expert who rated the submissions as appropriate had greater healthcare experience than other raters, which may indicate that the positive rater was able to infer the appropriateness based on personal experience. Comments by the two other raters, such as, "No indication...that this design is appropriate" and "Does not appear to fit the existing ecology..." suggest that the conceptual designs submitted did not adequately specify the intended context of use. Overall, experts only agreed on the appropriateness of Team W2's design, which supports the design's overall high ranking (Figure 92).

The identified trend for experts to perceive the solutions proposed by W teams as more elegant than those proposed by WO teams (See Section 6.3.1.2.2) was supported by experts' comments. Experts noted that Team W1 and Team WO1's conceptual designs were not elegant and complained that Team WO4's submission was "over designed". Experts did not provide any positive or negative comments regarding the perceived elegance of the solutions submitted by the remaining teams (i.e., W2, W3, W5, WO2, WO3).

Table 66. Highlighted statements from experts' critiques of WO teams' conceptual designs

| Team | Critique of Conceptual Design | | | |
|---------------|---|---|---|--|
| Functionality | Usability | ER Appropriateness | Design Elegance | |
| WO1 | The usability of this system is suspect. | ...Does not appear to be a good fit to existing ecology of a hospital. | I do not think the design is elegant, or more importantly, it didn't provide clear visual cues to aid the user. | |
| | | ...Very appropriate and needed in the ER setting. | | |
| WO2 | The proposed conceptual design does appear to enhance or improve the current BCMA systems | The conceptual design requires the user to obtain and administer the medication which still leaves opportunity for error. | ...Appropriate for ER setting. | |
| | | No indication...that this design is appropriate | | |
| WO3 | ... too many possibilities for use errors that could lead to adverse events | Would interrupt the current workflow for the ER setting. | | |
| | Given the very basic concept, there are not many usability problems. | | | |
| WO4 | The fact that the design doesn't adequately address the functional needs makes the usability needs a bit of a moot point. | Nothing in the rationale, description, or design that suggests this is uniquely suited for the ER | I didn't think it was elegant because it seemed over-designed | |
| | | ...Appropriate for ER setting | | |

Table 67. Highlighted statements from experts' critiques of W teams' conceptual designs

| Team | Critique of Conceptual Design | | | |
|-----------|---|---|--|---|
| | Functionality | Usability | ER Appropriateness | Design Elegance |
| W1 | | The interaction design on the device is cumbersome and inefficient. | ...Underscored a potential lack of contextual understanding that transcripts and personal experience cannot provide. ...Appears to fit the hospital ecology | The solution itself does not seem particularly elegant or innovative. |
| W2 | | The result is a good user experience for all. | ...A lot of potential usage in the ER setting | |
| W3 | A major functional need that was left out but would be required for this design to work is network security | | ...May be hard in a rush and stress environment. | |
| W5 | | | The laptop reference seemed contrary to the nature of many ERs - a quick, flexible, unpredictable take-action kind of environment. | |

6.3.1.2.4 Summary of findings – RQ2b

Table 68. Summary of findings for RQ2b

| Hypothesis | Finding | |
|---|----------------------------|--|
| RQ2b: Teams with the framework analysis instructions (i.e., W teams) will receive significantly higher rankings than those without (i.e., WO teams) | Partially supported | Trend for W teams to receive higher usability rankings than WO teams |

6.4 Discussion

6.4.1 *RQ2a: Impact of the framework’s analysis instructions on designers’ ability to identify user needs.*

Differences in the quality of the user need sets between WO and W teams were used to discern the impact of the framework’s analysis instructions on designers’ ability to identify user needs from stakeholder stories. Similar to RQ1a-3 (See Section 5.3.1) quality was operationally defined by each set’s breadth (i.e., coverage of all possible user need categories) and depth (i.e., quantity of user needs within each category). No differences in depth were found between teams that utilized the framework’s instructions and teams that did not. Teams that did not cover all categories (i.e., WO1, W1, W2, W5) tended not to identify hygienic and/or physical user needs. Considering the findings for RQ1a-2 (See Section 5.3.2) in which stakeholders in general neglected to contribute hygienic and physical needs, the inability for teams to identify these elusive needs was not surprising. However, since some teams did manage to identify a few hygienic and physical needs, this suggests an opportunity for improvement of the existing framework. In addition to changing the protocol to target the elicitation of these specific types of needs (See Section 5.5.2), the analysis instructions within the framework may be modified to facilitate identification of these needs. In the current instructions (Appendix C.5.5) designers identify all context-of-use needs within Step 3. However, given the difficulty for some teams to identify physical and hygienic needs, the inclusion of an additional step that targets these specific

needs may improve the framework. This prospective change to the analysis instructions may be explored in future work.

It was hypothesized that W teams would identify a greater depth of user needs than WO teams; this hypothesis was not supported. One interpretation is that the quantity of user needs may not be the best indicator of differences between sets when comparing user needs across design teams (i.e., different designers / analysts). Although this approach is appropriate when comparing user needs across sessions evaluated by the same analysts (i.e., RQ1) as the same user needs are compared across groups, it may have limitations when used across teams that have created similar, yet different, user needs.

The finding that teams with less conceptual design expertise tended to identify a greater quantity of user needs further supports the interpretation that this metric may not be an appropriate benchmark for comparing user need sets across design teams. Designers' ability to synthesize information may be related to the quantity of needs identified since designers with less expertise have less experience synthesizing information into user needs. One may view user needs analysis as an iterative process of identifying and synthesizing information. In fact, the framework's current analysis instructions were rooted in a thematic analysis process to leverage similarities between the two analysis activities. For example, during the first step of thematic analysis, chunks of information relating to the research question are initially identified and classified as nodes. Nodes similar in meaning are then synthesized to form codes and, in turn, similar codes are grouped into themes (Creswell, 2007). User needs analysis is quite similar as user needs (i.e., themes) are identified in an effort to answer a design problem. Although the framework instructions provide guidance for the identification and specification of user needs, the instructions assume designers' expertise in synthesizing information into user needs. Guidance for the synthesis of information was purposefully excluded in an effort to create a process that could be used in a "real world" design situation. Although this additional process would improve the rigor of the current instructions, it would also increase analysis time, which is not an appropriate trade-off in design situations where time-to-market is a competitive advantage.

Future work may explore comparisons of the W and WO teams' needs sets using different approaches. For example, additional analyses of the characteristics of each set that were explored in RQ2a-2 (i.e., emphasis, dispersion) may provide further insight into potential

differences between the WO and W teams' needs sets. In addition, future work may recruit stakeholder experts to rank the entire sets identified by each team. This work limited expert rankings to conceptual designs for a chosen design opportunity (i.e., Lab 4), but future work should explore rankings for the entire set identified from stakeholder stories (i.e., Labs 1 and 2).

Discrepancies in the synthesis abilities between teams may explain why efforts to compare individual needs between W teams and the ideal set were unsuccessful (See Section 6.2.7.1). For example, Team W2's set, which experts praised as "strong", identified "check chart before giving medicine" as a usability need. In contrast, Team WO2's set, which experts criticized as "vague", included two similar needs "administer medicine" and "check patient allergies". These user needs could be further synthesized into the more specific need, which still fits the grammar rules imposed by the framework: "check chart for patient allergies before giving medicine". Future work may explore the use of the analysis instructions within an experienced real-world design team to investigate if Team W2's success is replicable within a real-world design task. Since Team W2 was a team with a self-reported high level of conceptual design experience, it is hypothesized that an experienced design team would also be able to specify a quality needs set through utilization of the framework's instructions.

Research question RQ2a-2 explored the differences between user needs identified by teams that followed the analysis instructions (i.e., W teams) with the ideal set identified by qualitative analysts. Set characteristics, including the emphasis and dispersion of user needs, were used to guide comparisons. Emphasis was an indicator of a team's tendency to identify a greater quantity of functional, usability and/or context-of-use needs. Dispersion was a measure of a team's tendency to categorize user needs as relating to functional, usability, and / or context-of-use. The original hypothesis that there would be no significant differences between the ideal set and Team W's sets was unsupported. In fact, no set matched the ideal set in terms of both emphasis and dispersion. The ideal set emphasized context-of-use over usability and functional needs, which provides additional support to previous work which identified an increased understanding of the context-of-use as a benefit of storytelling as an elicitation method (Gausepohl et al., 2011). However, none of the W teams emphasized context over usability and/or functional needs. One potential explanation may be the qualitative analysts' use of the grounded theory method of constant comparisons in addition to the analysis instructions used by design teams. Upon completion of one storytelling session's analysis, qualitative analysts were

instructed to revisit previous transcripts to double check if newly created user need(s) were discussed in previous sessions as well. The constant comparison method may facilitate the identification of a greater variety of context-of-use information as analysts revisit previous transcripts with the context(s) of the recently read transcript in working memory. These iterative comparisons may have allowed qualitative analysts to identify slight variations in context that were not apparent to student designers who analyzed one file that contained all stories. As none of the W teams emphasized context-of-use needs, alterations to the analysis instructions that facilitate an emphasis on context should be explored in future work. The constant comparative method was purposefully excluded from the analysis instructions in an effort to reduce overhead associated with the process (i.e., time requirements, updates to the user needs set between iterations, etc....). However, the analysis instructions may be modified to include the constant comparative method during design tasks in which an understanding of the context-of-use is essential for success. For example, designers may view the trade-off between time and an increased number of context-of-use needs during a design task in an unfamiliar domain.

Three of the five teams (i.e., W1, W2, W4) matched the ideal set in terms of dispersion. The overlap between functional needs with usability and context-of-use needs was small, which reinforces the desired separation between functional and usability needs. The other two teams created sets with a relatively large overlap between functional and usability needs, which indicates confusion regarding the distinction between “what” the solution needs to do and “how” it needs to do it. The use of students as proxies for professional designers may have contributed to this finding. One possible explanation may be the observed tendency for students to form assignment submissions motivated by the desired grade and not by the specifications. For example, the primary student question in response to the Lab 1 and 2 assignments was, “How many functional/usability needs do you expect us to submit?” Although we emphasized that submissions would not be graded in terms of sheer quantity of needs, we suspect teams such as W5 and W6 intentionally blurred the boundaries between functional and usability needs in an effort to bolster the quantity of needs within each category and chances for a higher grade.

Similar to RQ2a-1 experience may have also been a factor. For example, teams W5 and W6 self-reported a low level of previous experience with usability engineering and the teams’ sets reflected this inexperience. As these teams created sets that did not adequately make a distinction between functional and usability needs, it suggests that either the lab introductory

materials or analysis instructions may not have been suitable for novices in usability engineering. However, since one of the goals of the storytelling framework is to provide guidance to designers new to usability, future work should explore potential changes to the instructions to improve novice's ability to distinguish between functional and usability needs. Since basic understanding of the distinction between usability and functional needs eluded Teams W5 and W6, this suggests that the definitions provided in the framework may need to be updated. In addition, an online interactive practice exercise could be incorporated into the instructions to ensure proficiency in the analysis method before designers incorporate the storytelling framework into a real-world design problem.

6.4.2 RQ2b: Impact of the framework's analysis instructions on designers' ability to identify a design opportunity.

Experts' rankings of students' conceptual designs were used to discern the framework's impact on designers' ability to identify a design opportunity documented within a conceptual design. The results indicated a trend for experts to assign higher usability ranks to conceptual designs created by teams that utilized the analysis instructions (i.e., W teams) than teams that did not (i.e., WO teams). This finding suggests that the analysis instructions provided additional guidance for the consideration of usability within W teams' designs. Although this finding supports the efficacy of the analysis instructions during a design task, further research is required to identify which component(s) of the instructions facilitated the creation of a usable conceptual design. For example, the W teams' instructions differed from the WO teams' instructions in several aspects (Table 69). In contrast to the instructions provided to the WO teams, the framework's instructions provided to W teams included: (1) the use of structural analysis to transform nurses' stories into concise narratives (2) an iterative approach for the identification of usability needs and (3) grammar rules to guide the specification of identified needs. Since this work suggests that the instructions as a whole guide designers towards the creation of usable designs, future work may explore how individual aspects of the framework's instructions influence design. Additional knowledge of how components of the instructions negatively or positively influence design will provide further insight into potential changes to the framework's analysis approach.

Table 69. Potential directions for future work

| Components of Instructions | Intended Purpose(s) | Potential Directions for Future Work |
|-----------------------------------|---|--|
| Structural analysis | Encourage data organization and reduction (i.e., transform nurses' stories into concise narratives) | How does the increased analysis time imposed by the additional structural analysis step influence designers' focus on usability? How do narratives support designers' communication and memory of usability concerns? |
| | Iterative approach | Guide designers in the identification of usability needs associated with previously identified functional needs |
| Grammar rules | Encourage specification consistency | How does the increased analysis time imposed by the additional iterations influence designers' focus on usability? How do the constraints imposed by the grammar rules influence designers' ability to synthesize information into usability needs? |
| | Guide designers in the identification of usability needs associated with previously identified functional needs | How do the constraints imposed by the grammar rules influence designers' ability to specify usability needs? How do the grammar rules guide designers towards the identification of usability needs? |

For example, one possible interpretation of the finding that W teams tended to create more usable designs than WO teams is that the additional structural analysis step positively influenced design. Since the introduction of an additional analysis step also required designers to spend more time analyzing nurses' stories, the gains in usability understanding may be associated with the amount of time designers spent reading (and re-reading) stories. Although the structural analysis step did not require designers to start thinking about user needs, the process imposed during structural analysis may have prompted designers to start thinking about user needs.

Since designers were tasked with ordering stories in terms of narrative components (i.e., abstract, orientation, complicating action, resolution, evaluation), the process itself may have helped designers form associations between nurses' statements and potential user needs. For example, the identification of orientation statements, which summarized contextual details leading up to the story, may have helped W team designers identify context-of-use of user needs. Since the instructions provided to WO teams did not include this structural analysis activity, usability deficiencies in the WO teams' designs may have been partially influenced by a missed opportunity to create associations between stakeholder statements and user needs.

The framework's use of narratives as the data source for user needs analysis may have also influenced designers' ability to incorporate usability needs into the design. Unlike the free-form nurses' responses, the narratives created by W teams were concise and ordered representations of nurses' stories. Designers may have used the created narratives as cognitive schemas (Polkinghorne, 1988) that supported recall and discussion of user needs among team members.

The framework's iterative approach to user needs analysis may have also benefitted W teams. Since successful requirements engineering teams tend to view the specification as a "living document" (Hofmann & Lehner, 2001), the iterative approach enforced by the framework may have encouraged W teams to include more changes and revisions in comparisons to WO teams. However, as previously mentioned in Section 6.4.1, the framework's iterative approach should be enhanced with guidance for the synthesis of user needs between iterations. Although Team W2 exhibited the ability to synthesize user needs between iterations, team members' previous experience with conceptual design creation may have compensated for the lack of synthesis guidance within the current instructions.

The grammar rules imposed by the framework may have also influenced W teams' ability to incorporate usability within conceptual designs. The grammar rules were intended to encourage consistency within the specification and to facilitate identification of usability needs for previously identified functional needs. Students' expressed varied reactions to the grammar rules during de-briefing sessions at the beginning of lab exercises. While some teams expressed frustration adhering to the grammar rules, other teams appreciated the assistance the rules provided. For example, one student mentioned that the grammar rules helped reduce confusion during team discussions. The student noted that when team members referenced particular user needs the student would identify the needs' grammar in an effort to infer what usability category the team was discussing (e.g., "We're talking about an efficiency need"). In contrast, other students expressed frustration in converting an identified need into the format prescribed by the grammar, which suggests that additional support may be required to ensure the feasibility of using the grammar rules during a design task. For example, a software tool could assist designers in the specification and organization of user needs that adhere to the grammar. Future work may explore how the grammar rules positively and negatively influence identification and specification of user needs.

Although no trends were found for differences in the functional or overall rankings between WO and W teams, analysis at the question level within critiques revealed that experts' tended to view W teams' designs as more elegant and innovative than WO teams' designs. However, the average agreement scores for the elegance ($M = 3.4$, $SD = 0.9$) and innovative questions ($M = 3.3$, $SD = 1.1$) was still at the "neutral" level, which suggests that the W teams' designs weren't viewed as particularly elegant nor innovative outside comparisons with WO teams. This finding suggests that although the framework guided designers towards an elegant and / or innovative solution, additional changes to the framework are required to ensure a meaningful change in the achieved elegance and innovativeness of designs. Since elegance is influenced by the simplicity of the design, additional changes in the framework that encourage information synthesis (See Section 6.4.1) may also encourage design elegance. Additional opportunities for information synthesis may also facilitate the identification of innovative solutions to the identified design problem. Future work may explore how adaptations to the current framework that encourage synthesis impact the resulting elegance and innovativeness of resulting conceptual designs.

6.5 Limitations

Since the investigation of the framework's analysis instructions during design practice was limited to a class project, future work should explore the impact of the instructions when utilized by professional designers. Since findings indicated that student designers' ability to synthesize user needs impacted the quality of the resulting user need set, future work should investigate if this is an issue with professional designers as well.

The restriction of stakeholder experts to design and engineering fields is another limitation of the study. Since experts disagreed on the appropriateness of some designs within a healthcare environment, additional critiques from healthcare stakeholders (i.e., nurses, patients, administrators) should be explored in future work.

The use of user needs as the unit of analysis is another limitation of this work. Future work should explore how the storytelling framework can facilitate the transformation of user needs into specific and testable requirements. Although the identification of user needs and the creation of a conceptual design is a first step towards transitioning between the problem space and solution space, additional work is required to investigate how storytelling can fully guide designers into the solution space. For example, previous work in capabilities engineering (Ramya Ravichandar, Arthur, & Broadwater, 2007) may be leveraged to provide the synthesis support necessary to facilitate transition into the solution space.

CHAPTER 7. CONCLUSIONS

7.1 Summary of the research

The overall goal of this research was to present storytelling as a knowledge elicitation method that addressed the Prevention through Design (PtD) call for methods that improve usability within healthcare. Towards this goal, we created the Design + Storytelling framework (Figure 8), which was informed by a conceptual model for the role of storytelling in design (Figure 7). The Design + Storytelling framework provides guidance for the identification of a design opportunity through the collection and analysis of stakeholders' stories. The specific instantiation of the framework explored during this work guides designers through problem exploration within an emergency room (ER) environment.

The guiding research question for this work, "What is the impact of the Design + Storytelling framework on design?" was supported by two research questions. These research questions investigated the impact of the framework's two primary stages (i.e., *Elicit Stories*, *Analyze Stories*) on design. RQ1 investigated the impact of four elicitation methods, which varied in context (i.e., setting, questions), on the user needs collected. The impact of the elicitation method on the user needs collected was determined through comparisons of the quantity of user needs, as well as comparisons of the quality of the compiled user need sets. Quality was determined through comparisons of the breadth (i.e., coverage across need categories) and depth (i.e., quantity of needs within each need category) of the compiled user need sets across methods.

RQ2 investigated the practical benefit of the framework's analysis instructions during a design task. Comparisons between design teams provided with the instructions and teams without were used to discern the impact of the instructions on design artifacts, including the identified user need set and resulting conceptual design for an identified design opportunity.

The research was conducted in three phases to address the identified research questions. In Phase 1, ER nurses' stories were collected using the four elicitation methods. Narrative analysts formed nurses' free-form stories into concise narratives using Labov & Waletzky's (1967) structural components. These narratives became the data source for the identification of user needs by thematic analysts within Phase 2. In Phase 3, teams of student designers created conceptual designs that addressed an identified design opportunity informed by ER nurses' stories. Section 7.1.1 through Section 7.1.3 summarize the key contributions of this work.

7.1.1 Conceptual model for the role of storytelling in design

As evidenced in our literature review in Chapter 2, stories are often cited within design literature as a means to facilitate the design process. Although design literature attributes improved communication between stakeholders and designers to the use of stories during design (Alvarez & Urla, 2002; Wagner & Piccoli, 2007), the current literature does not explicitly state how stories fit within the design process. Quesenbery & Brooks (2010) present stories as a means to brainstorm ideas during user experience (UX) design, but guidance for the analysis of stories during the concept stage of design is limited to the creation of personas. Guidance for additional analyses typically conducted during early stages of design, such as the identification of user needs within stakeholders' stories, is not provided.

Our conceptual model, which synthesizes narrative inquiry and design research, addresses this current gap in the literature. Our model presents storytelling as a method that consists of two processes: (1) the storytelling activity and (2) the storytelling analysis. The model's explicit separation of storytelling into elicitation and analysis processes provides additional focus, which is lacking in the literature. The lack of a consistent definition for story within design literature is due in part to the inconsistent use of story to refer to both the process and product of storytelling. For example, Alvarez & Urla (2002) refer to a story as "an embedded and fragmented process", which implies a process-centric view. In contrast, Kim, Lund, and Dombrowski (2010) refer to a story as defining "where technology and users mismatch", which implies a view of stories as the product of storytelling. To address this confusion, our conceptual model leverages Polkinghorne's (1988) process and product approach to storytelling. In our model, the storytelling activity (i.e., a process) results in the collection of

stakeholder stories (i.e., a product), which are explored by designers during storytelling analysis (i.e., a process) to identify a design opportunity informed by user needs (i.e., a product).

The primary implication of our conceptual model is that designers may alter the storytelling context to influence the information elicited from stakeholders. Although Quesenbery & Brooks (2010) provide practical recommendations for story elicitation, such as “Don’t get distracted” and “Create a structure that supports story collection”, the design literature as a whole lacks guidance for how to alter the storytelling context to elicit information relevant to a current design goal. Section 7.12 provides an overview of this study’s investigation of the Design + Storytelling framework, which aimed to: (1) provide practical design guidance for the selection of an appropriate storytelling elicitation method based on empirical findings and (2) evaluate the efficacy of the framework’s analysis instructions during design practice.

7.1.2 *The Design + Storytelling framework*

The conceptual model described in Section 7.1.1 informed the creation of the Design + Storytelling framework. For example, the representation of the storytelling method as two separate processes (i.e., storytelling activity, storytelling analysis) informed the creation of two distinct stages (i.e., *Elicit Stories*, *Analyze Stories*) within the framework. The overall goal of the framework was to guide designers’ use of storytelling during the concept stage of design.

Section 7.1.2.1 provides a summary of the findings of our investigation of the four elicitation methods utilized during the storytelling activity. Section 7.1.2.2 provides a summary of the findings of the application of the storytelling analysis guidance during design practice.

7.1.2.1 Investigation of elicitation methods

The study’s collection of 573 narratives (i.e., 441 habitual, 132 hypothetical) from 28 ER nurses facilitated the identification of 383 user needs (i.e., 130 functional, 301 usability). Comparisons of user needs across elicitation methods (i.e., IHH, GHH, IH, GH) indicated that storytelling context affected the user needs elicited. In terms of the quantity of user needs elicited during storytelling sessions, group sessions elicited significantly more user needs across the majority of usability categories than individual sessions. The discrepancy in the quantity of user needs elicited cannot be simply explained by time differences across methods, as group

sessions of average duration elicited a greater quantity of needs than individual sessions of average duration. As discussed in Section 5.4.1, the relative success of group sessions in comparison to individual sessions may be explained by differences in story details. For example, the inclusion of a co-worker in the storytelling session may have introduced an attentive listener who facilitated the collection of detail-rich stories (Dickinson & Gibson, 1995). The co-worker dyad within group sessions may have also facilitated collaborative remembering (Hyman, 1994), in which additional details were included during the co-construction of stories (Mishler, 1986).

Comparisons between the compiled set of user needs collected across methods also indicated that session context impacted the quality of the compiled user need set. Although no differences in breadth were found across compiled sets, differences in depth were found. Overall, the majority of hypotheses for depth were supported (See Section 5.4.3). As expected, the compiled GHH set had a greater depth of functional needs than the IHH, IH, and GH sets. This finding suggests that the GHH method was adept at the collection of unique functional information across sessions. This was expected due to the additional opportunities for collaborative storytelling within this method. For example, unlike GH stories, in which participants may co-construct habitual stories only, the GHH method provides the opportunity for participants to co-construct hypothetical stories as well. Since stories facilitate brainstorming (Quesenberry & Brooks, 2010), the inclusion of the additional hypothetical prompts within the GHH method was expected to encourage brainstorming of unique information. The finding that the GHH set had greater depth in functional needs suggests that the GHH method facilitated participant brainstorming of desired features. However, since no significant differences were found between the GHH and IHH sets in terms of usability and context-of-use depth, this suggests that either (1) the GHH method did not encourage brainstorming necessary for the elicitation of usability and context-of-use needs or (2) the GHH method did encourage brainstorming, but the elicited usability and context-of-use needs were not unique across sessions. Future work may explore the impact of brainstorming during group sessions on the user needs elicited using post-hoc analyses on the current data set.

The compiled G set (i.e., GHH, GH) had greater depth in functional, usability, and context-of-use needs than the compiled I set (i.e., IHH, IH). This finding suggests that storytelling sessions in a group setting elicit more unique functional, usability, and context-of-use needs than those conducted with only one storyteller. This finding suggests that

collaborative remembering not only results in the sharing of more detail-rich stories (Hyman, 1994), but in the sharing of user needs relevant to design.

In addition, the compiled HH set (i.e., GHH, IHH) had greater depth in functional, usability, and context-of-use needs than the compiled H set (i.e., GH, IH). This finding suggests that the inclusion of additional probes for hypothetical stories facilitated the collection of more distinct user needs across storytelling sessions. This finding was expected, as the purpose of the hypothetical prompts was to elucidate the gap between the current and ideal work environment.

The empirical findings from the investigation of the storytelling activity informed decision rules used to provide design guidance for the selection of a storytelling method for use within a given User Centered Design (UCD) task (Section 7.1.3). For example, since no significant differences were found between the compiled G and HH sets, designers may choose to conduct storytelling sessions using both GHH and IHH methods (i.e., collect an HH set) in situations where the sole use of groups is not possible due to time constraints or scheduling difficulties.

Our investigation of the storytelling activity also resulted in additional practical guidance for the development of question prompts used during storytelling sessions. We utilized context-free questions during this study, which prompted nurses to share experiences relating to an IOM quality aim. Based on our experiences, we suggest that designers pilot test question order to identify potential ordering effects. In our first storytelling session, we prompted the participant to initially share equitable care and patient-centered care stories. However, the participant expressed frustration in identifying and sharing stories relevant to the goal of the session, which was to discuss experiences relevant to medical device design. Since the participant expressed relief when we prompted for stories relating to patient and/or practitioner safety, we changed the storytelling script to prompt for safety stories first. In retrospect, we acknowledge that equitable and patient-centered care prompts are more difficult to relate to medical device design, but we did not proactively anticipate this problem. The re-ordering of question prompts allowed participants to get comfortable with the storytelling activity through the sharing of safety stories, which are more readily applicable to medical device design, before later prompts for equitable care stories. This re-ordering of question prompts improved the success of subsequent sessions, as participants were able to successfully share stories relating to equitable and patient-centered care.

Findings also indicated that additional changes to the storytelling protocols are necessary to facilitate the collection of hygienic and physical context information. Overall, participants did not include hygienic and physical details, which replicated findings of previous work (Gausepohl et al., 2011). One potential solution to this issue may be the addition of probes specific to hygienic and physical context within the storytelling protocol to encourage the elicitation of this information.

An overview of the framework's application during design practice follows.

7.1.2.2 Investigation of the framework's analysis instructions in design practice

The Design + Storytelling framework provides two types of instructions which guide designers' analyses of stories. First, designers utilize structural analysis instructions to restructure free-form stories into concise narratives. Second, designers utilize instructions for the identification of user needs within narratives. These instructions prescribe an iterative approach to user needs identification informed by an ontology for medical device requirements developed in previous work (Gausepohl et al., 2011). In addition, the instructions for the identification of user needs also provide grammar rules for the specification of identified needs.

Although measures of inter-coder reliability indicated that qualitative analysts were able to utilize the instructions successfully to identify an ideal set of user needs, additional investigation of the instructions' use within practice was necessary to: (1) investigate the impact of the instructions' use on subsequent design artifacts (i.e., user need sets, conceptual design) and (2) identify potential opportunities for improvement of the instructions.

It was hypothesized that teams provided with the framework's instructions (i.e., W teams) would identify a greater depth of functional, usability, and context-of-use needs than teams without the benefit of the framework's instructions (i.e., WO teams); however, comparisons across teams did not support this hypothesis. One potential explanation for this unexpected finding may be that a comparison of depth may not be an accurate measure of the quality of a user need set when used to compare sets across different teams of analysts/designers. Our previous comparisons of set depth restricted comparisons to sets identified within one team of thematic analysts. When compiled sets are compared within one set of analysts, a higher quantity of user needs within a category (i.e., increased depth) is an accurate indicator of quality since all compiled sets represent a subset of the total user needs identified. However, when

compared across teams of analysts/designers, depth may not be an accurate measure of quality because an increased quantity of needs within a category may actually indicate less synthesis of user needs. This interpretation is supported by experts' critiques of students' user need sets. For example, Team W2's set, which experts praised as "strong", identified *check chart before giving medicine* as a usability need. In contrast, Team WO2's set, which experts criticized as "vague", included two similar, yet separate, needs: *administer medicine* and *check patient allergies*. Team WO2's apparent lack of synthesis ability resulted in a lower quality set that contained a greater depth of user needs.

Although the discrepancies in synthesis abilities across design teams may be exaggerated due to the use of students as proxies for designers, this finding does indicate an opportunity for the improvement of the analysis instructions for the identification of user needs. Since one of the goals of the PtD initiative is to lower the threshold for engineers to engage in healthcare design, the Design + Storytelling framework should also accommodate novice designers. Although the current instructions provide guidance for the specification of user needs, the instructions lack guidance for the synthesis of related needs. The adaptation of the instructions to include guidance for the synthesis of needs is a direction for future work.

It was also hypothesized that the sets identified by W teams would not be significantly different than the ideal set identified by qualitative analysts. Since the depth of user needs proved to be an unreliable measure of quality when applied across teams of analysts/designers, sets were compared in terms of emphasis (i.e., focus on the identification on particular category(s) of user needs) and dispersion (i.e., categorization of needs as functional, usability and/or context-of-use). This hypothesis was also not supported as none of the W teams' sets matched the ideal set in both emphasis and dispersion. Since none of the W teams' sets emphasized the identification of context-of-use needs, which was the emphasis of the ideal set, this suggests a potential limitation of the instructions' use within design practice. One potential explanation may be that the qualitative analysts' use of constant comparisons facilitated the identification of additional context-of-use information. For example, these iterative comparisons may have allowed qualitative analysts to identify slight variations in context that were not apparent to student designers.

The findings provided partial support for the hypothesis that W teams' conceptual designs would receive higher rankings than WO teams' designs. Although no differences were found in functionality rankings between teams, differences in experts' usability ranks approached significance. Visual inspection of the usability ranks suggests that W teams received better usability ranks than WO teams. Future work is needed to provide insight into why W teams received higher usability rankings. For example, W teams' apparent emphasis on usability may be attributed to the increased analysis time imposed by the additional structural analysis step, and the additional iterations required during the identification of user needs.

The conceptual model and the Design + Storytelling framework represent the theoretical contributions of this work. An additional contribution of this work was the development of practical design guidance for the selection of a storytelling method.

7.1.3 Design guidance

Our exploration of the Design + Storytelling framework resulted in practical design guidance. First, designers may refer to our guidelines for the use of storytelling, which are based on lessons learned as a result of this project, to facilitate common goals (e.g., Gain facility entry). Second, designers may utilize the decision support tools to aid in the selection of an appropriate storytelling elicitation method for a chosen UCD task. Finally, designers may leverage the traceability inherent within the framework during design evaluation.

7.1.3.1 Guidelines for the use of storytelling in design

Lessons learned during the course of this work resulted in the creation of several guidelines for successful use of storytelling in design (Table 70). Each guideline addresses a specific goal (e.g., Encourage storyteller buy-in) within the design process. The guidelines provide guidance to various team members engaged in the storytelling method. The first three guidelines (i.e., *Confidentiality is key*, *Distinguish yourself from management*, *Ask questions meaningful to the storyteller*) provide recommendations for team members tasked with the elicitation of stories from stakeholders (i.e., the storytelling activity in Figure 4). The remaining guidelines (i.e., *Analyze separately and in groups*, *Leverage design standards*) provide guidance for team members tasked with transforming stakeholders' statements into design requirements

(i.e., the storytelling analysis in Figure 4). These team members may be usability, requirements, software, safety, and/or industrial engineers.

Table 70. Guidelines for the successful use of storytelling in design

| Goal | Guideline |
|---------------------|--|
| Gain facility entry | <p>Confidentiality is key. As our result of previous exploration of storytelling as an elicitation method, we presented several lessons learned for engineers gaining entry to a healthcare facility (Gausepohl, 2010). As a result of this study, we identified confidentiality as a key component to storytelling success, which extends beyond the utilization of storytelling within healthcare. Due to narrative's role in the construction of identity (Ezzy, 1998), storytelling has often been equated with the sharing of oneself. Although we anticipated hesitation by individual participants to share stories that may negatively impact his/her narrative identity, we did not expect to encounter administrator reluctance to storytelling. In addition to HIPAA concerns, such as the elicitation of confidential patient information, administrators expressed suspicion that the collected stories could (1) damage the facility's reputation in the area and/or (2) reveal proprietary information that could be used by the facility's competitors. We interpreted administrators' reluctance as a desire to protect the facility's narrative identity. We were only able to gain access to the facilities by ensuring confidentiality through: (1) de-identification of all session transcripts and (2) the report of user needs and not full stories. In addition, we</p> |

agreed to provide the over-arching corporate healthcare organization with the right of first refusal for all publications (including this dissertation) resulting from this work. This provided the corporate healthcare organization with the desired control over the information flow resulting from the storytelling sessions.

Encourage storyteller buy-in

Distinguish yourself from management. Although support from upper-management is necessary to gain entry into a facility, we found that our perceived alignment with administration negatively impacted our ability to achieve buy-in at the departmental manager and nurse level. To reduce suspicions that our research was a part of an administrative plan to cut resources within the emergency room, we expressed our distinction from management to the department by (1) utilizing our IRB liaison as an unbiased research champion who addressed potential participants' questions during staff meetings and (2) abandoning our "formal" suit attire, which was associated with management, in favor of a more university look of jeans and collegiate sweatshirt. We suspect that nurses' initial suspicion of storytelling was fueled by the desire protect one's narrative identity from being exposed to management. In this respect, it is necessary to distinguish the goals of the storytelling session from managements' goals to facilitate an

environment in which storytellers do not fear negative repercussions.

Elicit information relevant to design

Ask questions meaningful to the storyteller. In this work we were able to elicit information relevant to design through the use of context-free questions that addressed themes important to the storyteller (i.e., IOM quality aims). This approach addressed Maiden & Rugg's (1998) criticism of traditional interviews, which impose the interviewer's framework on the participant through the use of questions important to the interviewer and not the respondent. Since this research project demonstrated storytelling's ability to elicit design information through the use of questions that were not specific to design, we suggest that designers initially prompt storytellers with questions that address themes relevant to the storyteller before transitioning into prompts specific to design.

Analyze stories

Analyze separately and in groups. Although the initial purpose of our analyses approach was to reduce bias, we identified practical benefits from the use of both individual and group analyses. Based on our anecdotal observations, the initial separate analyses (i.e., narrative analysis, thematic analysis) by each analyst fostered engagement with the stories and a deep understanding of the stories' content. In contrast, the group analyses fostered discussion, which sparked debate about story interpretation. For example, we observed that

disputes regarding the identification of the complicating action during reconciliation of narrative analysis results typically evolved into discussion about the “main problem” and “what the solution would address”. Similarly, reconciliation meetings for thematic analysis also sparked debate for the identification and assignment of user needs to categories within the ontology. In our observations, analysts’ discussions regarding user needs’ assignments fostered understanding of connections between usability categories. For example, the assignment of a need (e.g., chart information quickly) within both the effectiveness and efficiency categories sparked discussion about potential tradeoffs between effectiveness and efficiency.

Identify user needs

Leverage design standards. Our use of a user needs ontology specific to healthcare (Gausepohl et al., 2011) facilitated our ability to identify design relevant information within stories. Since the ontology was created based on design standards specific to healthcare (ANSI/AAMI, 2009; IEC, 2007), we suggest that designers outside of healthcare reference relevant design standards to facilitate the identification of domain specific information.

7.1.3.2 Decision support tools for the selection of a storytelling elicitation method for a given UCD task

The decision support tools detailed in Section 5.4.3.2 support the selection of a method that elicits information relevant during the following common UCD tasks: (1) problem space exploration (2) specification of the context-of-use, (3) formative usability testing and (4) summative usability testing. For example, since successful specification of the context-of-use requires the elicitation of contextual information, the design guidance provides decision rules for the selection of the best method for the elicitation of this type of information. These decision rules were informed by empirical findings from the comparisons of elicitation methods summarized in Section 7.1.2.1. In an effort to provide comprehensive guidance to designers, additional user need sets (i.e., Mixed1 and Mixed2) were created to ensure an exhaustive comparison of all possible method combinations. Comparisons across all method combinations also ensured that our recommendations considered opportunities for triangulation, as designers are encouraged to utilize various methods (Garmer et al., 2002).

The decision support tools were also informed by a baseline decision tree, which determined the methods available to designers in consideration of potential real-world constraints, such as session time limitations and/or scheduling issues. In addition, the baseline decision tree does not restrict designers' decisions to binary Yes/No responses, which supports designers' ability to consider potential trade-offs in method selection. The baseline decision tree, in conjunction with the decision rules, supported the creation of specific decision support tools for the selection of a storytelling method for the four UCD tasks.

7.1.3.3 Evaluation support

The process imposed by the Design + Storytelling framework supports the traceability of design decisions back to stakeholders' specific statements (Figure 99), which is a recognized challenge within requirements engineering (Bittner, 2008). This traceability supports the evaluation of design decisions to ensure that all decisions were made in support of user needs, which is necessary within a UCD process. For example, each design feature within the documented design opportunity can be traced back to an identified user need. In turn, each user need can be traced back to an analyzed narrative statement and specific story statement. Each story statement may be referenced back to the original stakeholder.

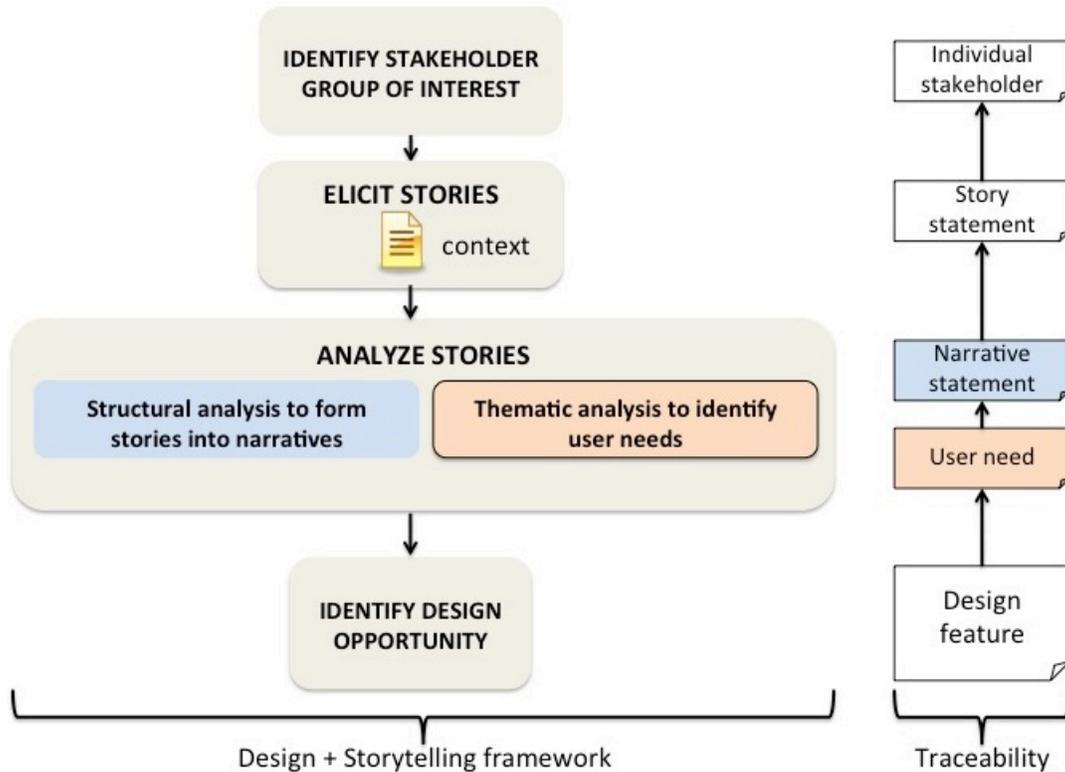


Figure 99. Framework's process supports traceability

7.2 Directions for future work

Further research is required to determine the generalizability of the Design + Storytelling framework. Since the current work limited the investigation to a single iteration of the framework that included only one type of stakeholder (i.e., nurses), future work should explore additional iterations in which other ER stakeholders (e.g., doctors, patients, pharmacists, laboratory technicians, hospital administrators) are included. Since findings indicated the compiled set of group sessions (i.e., GHH, GH) contained a higher quality of usability needs than other compilations, future work should explore if hierarchical differences between group storytellers impacts this gain. For example, power differences between administrators and laboratory technicians may impede brainstorming and/or collaborative storytelling necessary to elicit detailed stories.

This work also limited the investigation of the framework to an emergency room environment. Future work should explore the generalizability of the framework's ability to foster the identification of design opportunities within other healthcare areas (i.e., primary care

practices, home health, neonatal intensive care). In addition, future work should explore the generalizability of the framework in domains outside of healthcare, such as, consumer product design.

Future work should also investigate the use of targeted question prompts as this work limited questions to context-free questions relating to general IOM quality aims. Future work should explore the impact of the framework when question prompts constrain story sharing to a specific device or problem. Since the communication of patients' test results between the laboratory and the emergency department was cited as an issue, future work could utilize storytelling to explore this specific problem. In addition, future work should investigate how designers may leverage the storytelling framework in conjunction with other contextual inquiry techniques, such as observation.

Future work may also explore the generalizability of the Design + Storytelling framework to domains beyond healthcare to explore how the framework may facilitate NORA goals in other industries, such as construction. Since NORA provides research direction for NIOSH, improved prevention of workplace injuries may be achieved through application of the framework within NORA's identified research goals. Figure 100 represents an instantiation of the framework that targets the first strategic goal of the 2008 National Construction Agenda (NORA, 2008), which is to reduce construction work injuries and fatalities due to falls. One identified intermediate goal (i.e., Intermediate Goal 1.1) towards the strategic goal is to identify the top three fall-related problems through a partnership with construction stakeholders. As shown in Figure 100, the framework guides engineers through iterations in which various construction stakeholders (e.g., architects, builders, workers, etc...) are recruited to participate in storytelling sessions. Since the identified NORA goal is to identify fall-related problems, engineers are referred to the decision support tool for the selection of a storytelling method during problem exploration to ensure that engineers may maximize the success of storytelling sessions through alterations of the context (i.e., setting, questions). Engineers are guided to use question prompts to elicit information related to fall-related problems, such as "Please tell me about an experience that you had where fall-related problems were an issue" and/or "How would you re-write this story? For example, walk me through how this experience would have been in an ideal world."

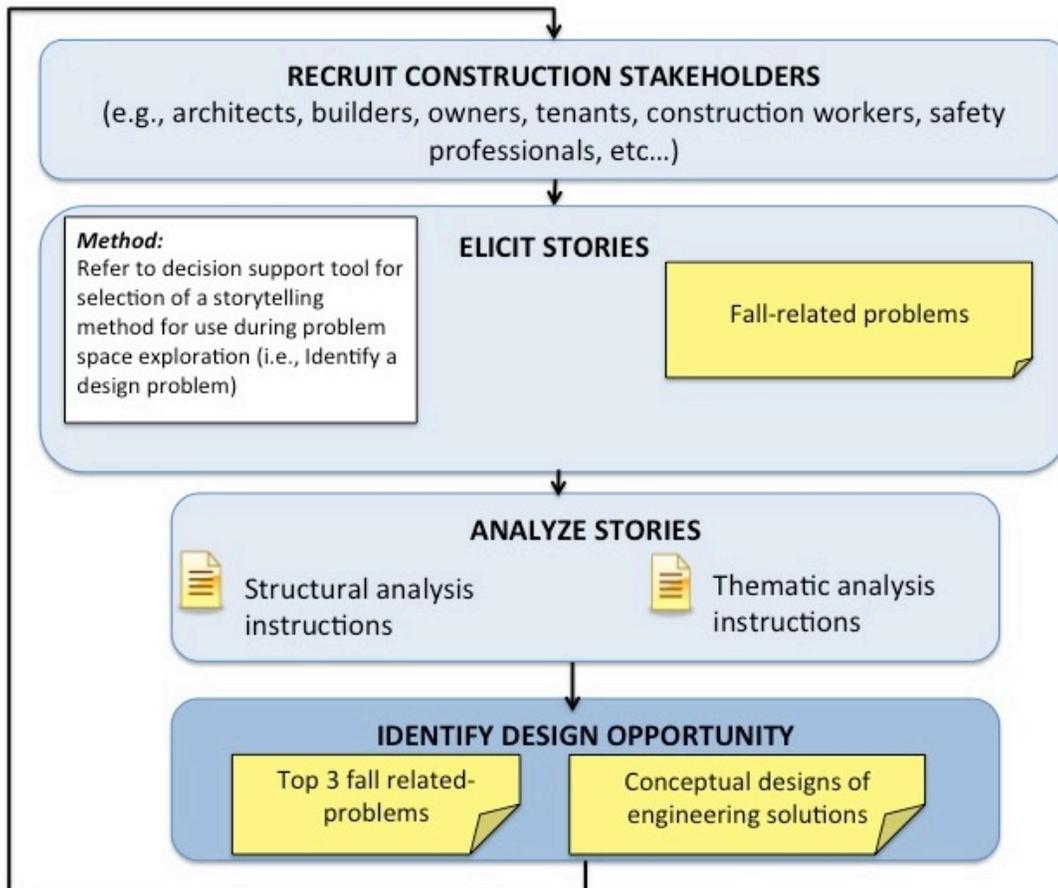


Figure 100. Instantiation of the Design + Storytelling framework within construction

Following this instantiation of the Design + Storytelling framework, engineers use structural analysis to form the collected stories into narratives, which in turn informs the identification of the top three fall-related problems. Engineers also use thematic analysis to identify user needs relevant to construction and/or fall prevention to inform the creation of conceptual designs that represent proposed engineering solutions that address the identified user needs.

Future explorations of storytelling’s utilization in domains outside of healthcare are not limited to product design. For example, NORA (2008) identified another intermediate goal (i.e., Intermediate Goal 1.2) that supports the reduction of injuries and fatalities due to falls. In this goal, NORA aims to expand awareness and use of existing fall prevention and protection solutions to construction stakeholders. Future work may explore how Denning’s (2004) “sparkling action” stories may be used to (1) expand awareness of the problem, (2) communicate the identified solutions, and (3) encourage buy-in among stakeholders . For example, the stories

collected by construction stakeholders in support of Intermediate Goal 1.1 may be used to expand awareness of the problem in support of Intermediate Goal 1.2. In this respect, future work may explore storytelling's impact in other areas outside of product design, such as, policy, procedure, and training systems creation.

The stories collected as part of this work also support future work outside of engineering. For example, as part of our agreement with the corporate healthcare organization, we performed secondary data analyses on the collected stories to identify strengths and opportunities for improvement (OFIs) within each hospital location. We provided customized reports to each hospital, which provided practical recommendations for the improvement of each OFI. In this respect, engineers' use of storytelling as an elicitation method may facilitate additional collaboration and buy-in with administrators at research sites as the research provided practical benefits to the organization. Secondary data analyses are not limited to the identification of OFIs. For example, administrators at a different hospital location indicated interest in the analysis of stories to identify instances of staff workarounds. Administrators planned to target additional training and process redesign efforts on these workarounds as part of a continuous improvement strategy.

We encourage researchers to explore opportunities for future work in storytelling due to the theoretical and practical benefits of this type of research. For example, our previous exploration of storytelling was referenced within a national news release of the Human Factors and Ergonomics Society (HFES) and was cited internationally by Siemens researchers as "innovative" (Boulila, Hoffman, & Herrmann, 2011). Future work should continue to close the identified PtD gap in healthcare since improved medical device usability has the potential to increase device sales, improve healthcare worker satisfaction, and improve patients' quality of care.

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Appendices

APPENDIX A: Phase 1 Documents

A.1 Virginia Tech IRB Approvals



VirginiaTech

Office of Research Compliance
Institutional Review Board
2000 Kraft Drive, Suite 2000 (0497)
Blacksburg, Virginia 24060
540/231-4606 Fax 540/231-0959
e-mail irb@vt.edu
Website: www.irb.vt.edu

MEMORANDUM

DATE: August 16, 2010

TO: Woodrow Winchester, Kimberly Gausepohl, James D. Arthur, Tonya L. Smith-Jackson, Brian M. Kleiner

FROM: Virginia Tech Institutional Review Board (FWA00000572, expires June 13, 2011)

PROTOCOL TITLE: Utilizing Storytelling Frameworks in the Concept Stage of Medical Device Design - Phase I

IRB NUMBER: 10-573

Effective August 16, 2010, the Virginia Tech IRB Chair, Dr. David M. Moore, approved the new protocol for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report promptly to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at <http://www.irb.vt.edu/pages/responsibilities.htm> (please review before the commencement of your research).

PROTOCOL INFORMATION:

Approved as: Expedited, under 45 CFR 46.110 category(ies) 5, 6, 7

Protocol Approval Date: 8/16/2010

Protocol Expiration Date: 8/15/2011

Continuing Review Due Date*: 8/1/2011

*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals / work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

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An equal opportunity, affirmative action institution



MEMORANDUM

DATE: March 3, 2011

TO: Woodrow Winchester, Kimberly Gausepohl, James D. Arthur, Tonya L. Smith-Jackson, Brian M. Kleiner

FROM: Virginia Tech Institutional Review Board (FWA00000572, expires October 26, 2013)

PROTOCOL TITLE: Utilizing Storytelling Frameworks in the Concept Stage of Medical Device Design - Phase I

IRB NUMBER: 10-573

Effective March 3, 2011, the Virginia Tech IRB Chair, Dr. David M. Moore, approved the amendment request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report promptly to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at <http://www.irb.vt.edu/pages/responsibilities.htm> (please review before the commencement of your research).

PROTOCOL INFORMATION:

Approved as: Expedited, under 45 CFR 46.110 category(ies) 5, 6, 7

Protocol Approval Date: 8/16/2010

Protocol Expiration Date: 8/15/2011

Continuing Review Due Date*: 8/1/2011

*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals / work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

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MEMORANDUM

DATE: July 20, 2011

TO: Woodrow Winchester, Kimberly Gausepohl, James D. Arthur, Tonya L. Smith-Jackson, Brian M. Kleiner

FROM: Virginia Tech Institutional Review Board (FWA00000572, expires May 31, 2014)

PROTOCOL TITLE: Utilizing Storytelling Frameworks in the Concept Stage of Medical Device Design - Phase I

IRB NUMBER: 10-573

Effective August 16, 2011, the Virginia Tech IRB Chair, Dr. David M. Moore, approved the continuation request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report promptly to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at <http://www.irb.vt.edu/pages/responsibilities.htm> (please review before the commencement of your research).

PROTOCOL INFORMATION:

Approved as: Expedited, under 45 CFR 46.110 category(ies) 5, 6, 7

Protocol Approval Date: 8/16/2011 (protocol's initial approval date: 8/16/2010)

Protocol Expiration Date: 8/15/2012

Continuing Review Due Date*: 8/1/2012

*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals / work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

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MEMORANDUM

DATE: January 30, 2012

TO: Woodrow Winchester, Kimberly Gausepohl, James D. Arthur, Tonya L. Smith-Jackson, Brian M. Kleiner, Varsha Doggala

FROM: Virginia Tech Institutional Review Board (FWA00000572, expires May 31, 2014)

PROTOCOL TITLE: Utilizing Storytelling Frameworks in the Concept Stage of Medical Device Design - Phase I

IRB NUMBER: 10-573

Effective January 27, 2012, the Virginia Tech IRB Chair, Dr. David M. Moore, approved the amendment request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report promptly to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at <http://www.irb.vt.edu/pages/responsibilities.htm> (please review before the commencement of your research).

PROTOCOL INFORMATION:

Approved as: Expedited, under 45 CFR 46.110 category(ies) 5, 6, 7

Protocol Approval Date: 8/16/2011 (protocol's initial approval date: 8/16/2010)

Protocol Expiration Date: 8/15/2012

Continuing Review Due Date*: 8/1/2012

*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:

Per federally regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals / work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

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A2. Informed Consent Form

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY Informed Consent for Participants in Research Projects Involving Human Subjects

Title of Project: **Utilizing Storytelling Frameworks in the Concept Stage of Medical Device Design**

Investigator(s) Kim Gausepohl, Dr. Woodrow Winchester, Dr. James D. Arthur, Dr. Tonya Smith-Jackson, Dr. Brian Kleiner

I. Purpose of this Research/Project

Medical device design impacts both the medical practitioner as well as the patient receiving treatment via the device. The purpose of this study is to investigate the efficacy of different requirements elicitation methods for medical devices in an effort to improve communication between healthcare workers and medical device designers.

40 participants will participate in this research project. Participants will be adult healthcare workers.

II. Procedures

Individual Narrative Interview:

If chosen for an individual narrative interview, you will meet individually with the researcher for approximately one hour. During the session, you will be asked to tell 9 stories relating to your workday experiences. Each story will be framed within a certain theme (e.g., patient safety, your safety, patient-centeredness, etc....) The proceedings of the sessions will be audio-taped for later analysis. However, nothing will be released which could potentially identify you, your patients, or your facility with your response. You are free to refuse to tell a story and to leave the session at any time without penalty.

If possible, interviews will be conducted in a private room on your healthcare facility's campus. If accommodations are not available at your workplace, the interview will be conducted in a private room located on the Virginia Tech (VT) campus.

Group Narrative Interview:

If chosen for a group narrative interview, you will meet with the researcher and 3-4 additional healthcare workers for approximately one hour. During the session, you will be asked to tell or contribute to 18 stories relating to your workday experiences. Each story will be framed within a certain theme (e.g., patient safety, your safety, patient-centeredness, etc....) The proceedings of the narrative interviews will be audio-taped for later analysis. However, nothing will be released which could potentially identify you, your patients, or your facility with your response. You are free to refuse to tell a story and to leave the session at any time without penalty.

If possible, sessions will be conducted in a private room on your healthcare facility's campus. If accommodations are not available at your workplace, the interview will be conducted in a private room located on the Virginia Tech (VT) campus.

III. Risks

No more than minimal risk. You may feel uncomfortable sharing opinions and experiences with the researcher or other healthcare workers. To minimize this distress the researcher will establish guidelines for the discussion. For example, participants will be instructed not to interrupt or judge others during the group discussion.

You may feel self-conscious creating stories during the interviews. You can refrain from telling a story for any theme that makes you uncomfortable.

You may feel uncomfortable if you are asked a question to which you do not have a response. You can refuse to answer any question without penalty.

Please note that there are no right or wrong answers and that all information you provide is valuable.

IV. Benefits

Potential benefits include the opportunity to discuss requirements with colleagues and the opportunity for greater understanding of your own work experiences.

Please note that no promise or guarantee of benefits have been made to encourage you to participate.

V. Extent of Anonymity and Confidentiality

All information gathered from you is confidential. Information gathered from you will be coded to remove information that directly identifies you, your patients, or your facility.

You will be assigned a participant number, such as P1, which will be used as identifiers in lieu of names. Information that associates you with your assigned number will be stored in a locked drawer in Whittemore 519C. In addition, the phrase "mid-size city hospital" will be used in lieu of your facility name.

Any potentially identifying patient information (e.g., names, ages, dates) will be removed from the transcripts.

Audio of the sessions will be digitally recorded. Within one hour of the session, the digital file will be transferred from the recording device to a password protected external drive. The digital file will then be deleted from the recording device. The audio files will be stored on the drive in a locked cabinet located in Whittemore 519C under the supervision of the primary researcher.

All audio recordings will be deleted from the laptop within 90 days from the date of the last recording.

It is possible that the Institutional Review Board (IRB) may view this study's collected data for auditing purposes. The IRB is responsible for the oversight of the protection of human subjects involved in research.

In some situations, it may be necessary for an investigator to break confidentiality. If a subject is believed to be a threat to herself/himself or others, the investigator will notify the appropriate authorities.

VI. Compensation

You will be compensated \$25 for your participation in the interview.

VII. Freedom to Withdraw

You are free to withdraw from a study at any time without penalty. You are free not to answer any questions or respond to experimental situations that you choose without penalty.

VIII. Subject's Responsibilities

I voluntarily agree to participate in this study. I have the following responsibilities:

- Participation in one 60 minute narrative inquiry interview

IX. Subject's Permission

I have read the Consent Form and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent:

_____ Date _____
Subject signature

Should I have any pertinent questions about this research or its conduct, and research subjects' rights, and whom to contact in the event of a research-related injury to the subject, I may contact:

Investigator(s) Telephone/e-mail
Kim Gausepohl
kgausepo@vt.edu
540-449-4769

Faculty Advisor Telephone/e-mail
Dr. Woodrow W. Winchester III
wwwinche@vt.edu
540-231-5936

Departmental Reviewer/Department Head Telephone/e-mail
David M. Moore
Chair, Virginia Tech Institutional Board for the Protection of Human Subjects
Office of Research Compliance
2000 Kraft Drive, Suite 2000 (0497)Blacksburg, VA 24060
540-231-4991
moored@vt.edu

[NOTE: Subjects must be given a complete copy (or duplicate original) of the Signed Informed Consent.]

A.3 Study Advertisement

Nursing Experiences Research Study



Call for participation in a Virginia Tech research study

Are you:

- An Emergency Dept (ED) nurse?
- Interested in sharing & reflecting on your work experiences?
- Interested in collaborating with colleagues?
- Interested in improving communication between healthcare practitioners and medical device designers?

If so, please consider participating as a stakeholder in this research project.

Participation includes:

- a 1-hour interview

If interested, please contact:

Kim Gausepohl
kgausepo@vt.edu
540-449-4769

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Kim Gausepohl kgausepo@vt.edu 540-449-4769 |
|---|---|---|---|---|---|---|---|---|---|

A.4 Demographic Questionnaire

Participant Background Questionnaire

Name: _____

Preferred Contact Method (circle one):

Email: _____

Phone: _____

Work Location: _____

Work Title: _____

Age: _____

Gender: _____

Nursing experience (years & months) _____

A.5 Scripts

A.5.1 Storytelling Session Script – Method IHH

[Adapted from Shield et. al. (2005)]

Introduction

My name is [INTERVIEWER'S NAME], and I am a graduate student in [DEPARTMENT NAME] at Virginia Tech. The goal of today's storytelling session is to improve our understanding of healthcare worker's work environments and experiences so we can design products to meet your needs.

Informed consent

Before we begin, there are a couple of important things that I need to go over with you.

- First, your participation in this interview is completely voluntary.
- If you decide not to participate, it will not affect you in any way.
- If there is any question you would rather not answer, just tell me and I will skip it.
- Most sessions take about 55 minutes or as long as you have.
- You can stop the session at any time, or we can reschedule the remainder of the session for another time.

We consider this discussion to be confidential. Your participation is confidential in the sense that your name will not be used in any reports or articles.

- We would like you to read this Informed Consent Form from Virginia Tech.
- Do you have any questions about this form or about our study?
- If you agree to proceed, please sign and date the form.
- Also, please note that we would like to record this conversation, but we need your consent in order to do so. You must indicate your agreement, or non-agreement, with audio taping on the consent form.

If the participant does not sign the form or chooses to leave before starting the interview: thank you very much for your time and willingness to hear about our work.

If the participant signs the form: thank you for signing this form. Please remember that this is a voluntary interview, which you may leave at any time.

I am turning the tape recorder on now. Just for our records, do I have your permission to tape this conversation?

Background Information

This session will be more of a conversation rather than a series of questions. In this interview, we would like to hear your stories about your work experiences. Stories such as yours, that tell us what went well and what could have gone better will help us to understand how improvements can be made. As you tell your story, please do not use the real names of people included in your stories.

I'll be asking you to share your stories/experiences with themes directed at IOM quality

aims. As a guideline, we're looking for stories like you would tell friends/family when they ask "how was work today?" (i.e., fairly detailed but within HIPAA guidelines). As part of my dissertation these stories will be used by industrial design students to inspire new products/designs that address unmet nursing needs.

Do you have any questions about the study?
May we continue?

[TURN ON RECORDER]

Before we get started, please tell me about your experience working here. In other words, please tell me "your story".

How would you re-write this story? For example, walk me through how your work experience should be in an ideal world.

Questions:

Safe (patient)

The first question is about patient safety. Please tell me that story about an experience you had where patient safety was an issue.

How would you re-write this story? For example, walk me through how this experience would have been in an ideal world.

Safe (practitioner)

The next question is about nurse safety (e.g., your own personal safety and/or the safety of your co-workers). Please tell me a story about an experience you had where practitioner safety was an issue.

How would you re-write this story? For example, walk me through how this experience would have been in an ideal world.

Effective

The next question is about effective care (e.g., barriers to providing effective care). Please tell me a story about an experience you had where care effectiveness was an issue.

How would you re-write this story? For example, walk me through how this experience would have been in an ideal world.

Patient-centered

The next question is about patient-centered care. Please tell me a story about an experience you had where patient-centered care was an issue.

How would you re-write this story? For example, walk me through how this experience would have been in an ideal world.

Timely (patient)

The next set of questions is about timeliness. Please tell me a story about an experience you had where patient timeliness (e.g., delay in care) was an issue.

How would you re-write this story? For example, walk me through how this experience would have been in an ideal world.

Timely (practitioner)

Please tell me a story about an experience you had where practitioner timeliness (e.g. where either you or a coworker experienced a delay in a task) was an issue.

How would you re-write this story? For example, walk me through how this experience would have been in an ideal world.

Efficient

The next set of questions is about efficiency. Please tell me a story about an experience you had where efficiency (e.g., waste in equipment, ideas, energy) was an issue.

How would you re-write this story? For example, walk me through how this experience would have been in an ideal world.

Equitable

The next set of questions is about equitable care. Please tell me a story about an experience you had where equitable care (e.g. barriers to providing quality care to everyone) was an issue.

How would you re-write this story? For example, walk me through how this experience would have been in an ideal world.

Close Interview

Is there anything else you would like us to know about your work experiences?

Thank you for taking the time to speak with me today.

A.5.2 Storytelling Session Script – Method IH

[Adapted from Shield et. al. (2005)]

Introduction

My name is [INTERVIEWER'S NAME], and I am a graduate student in [DEPARTMENT NAME] at Virginia Tech. The goal of today's storytelling session is to improve our understanding of healthcare worker's work environments and experiences so we can design products to meet your needs.

Informed consent

Before we begin, there are a couple of important things that I need to go over with you.

- First, your participation in this interview is completely voluntary.
- If you decide not to participate, it will not affect you in any way.
- If there is any question you would rather not answer, just tell me and I will skip it.
- Most sessions take about 55 minutes or as long as you have.
- You can stop the session at any time, or we can reschedule the remainder of the session for another time.

We consider this discussion to be confidential. Your participation is confidential in the sense that your name will not be used in any reports or articles.

- We would like you to read this Informed Consent Form from Virginia Tech.
- Do you have any questions about this form or about our study?
- If you agree to proceed, please sign and date the form.
- Also, please note that we would like to record this conversation, but we need your consent in order to do so. You must indicate your agreement, or non-agreement, with audio taping on the consent form.

If the participant does not sign the form or chooses to leave before starting the interview: thank you very much for your time and willingness to hear about our work.

If the participant signs the form: thank you for signing this form. Please remember that this is a voluntary interview, which you may leave at any time.

I am turning the tape recorder on now. Just for our records, do I have your permission to tape this conversation?

Background Information

This session will be more of a conversation rather than a series of questions. In this second interview, we would like to hear your stories about your work experiences. Stories such as yours, that tell us what went well and what could have gone better will help us to understand how improvements can be made. As you tell your story, please do not use the real names of people included in your stories.

I'll be asking you to share your stories/experiences with themes directed at IOM quality aims. As a guideline, we're looking for stories like you would tell friends/family when they ask "how was work today?" (i.e., fairly detailed but within HIPAA guidelines). As part of

my dissertation these stories will be used by industrial design students to inspire new products/designs that address unmet nursing needs.

Do you have any questions about the study?
May we continue?

Before we get started, please tell me about your experience working here. In other words, please tell me “your story”.

Questions:

Safe (patient)

The first question is about patient safety. Please tell me that story about an experience you had where patient safety was an issue.

Safe (practitioner)

The next question is about nurse safety (e.g., your own personal safety and/or the safety of your co-workers). Please tell me a story about an experience you had where practitioner safety was an issue.

Effective

The next question is about effective care (e.g., barriers to providing effective care). Please tell me a story about an experience you had where care effectiveness was an issue.

Patient-centered

The next question is about patient-centered care. Please tell me a story about an experience you had where patient-centered care was an issue.

Timely (patient)

The next set of questions is about timeliness. Please tell me a story about an experience you had where patient timeliness (e.g., delay in care) was an issue.

Timely (practitioner)

Please tell me a story about an experience you had where practitioner timeliness (e.g. where either you or a coworker experienced a delay in a task) was an issue.

Efficient

The next set of questions is about efficiency. Please tell me a story about an experience you had where efficiency (e.g., waste in equipment, ideas, energy) was an issue.

Equitable

The next set of questions is about equitable care. Please tell me a story about an experience you had where equitable care (e.g. barriers to providing quality care to everyone) was an issue.

Close Interview

Is there anything else you would like us to know about your work experiences?

Thank you for taking the time to speak with me today.

A.5.3 Storytelling Session Script – Method GHH

[Adapted from Shield et. al. (2005)]

Introduction

My name is [INTERVIEWER'S NAME], and I am a graduate student in [DEPARTMENT NAME] at Virginia Tech. The goal of today's storytelling session is to improve our understanding of healthcare worker's work environments and experiences so we can design products to meet your needs.

Informed consent

Before we begin, there are a couple of important things that I need to go over with you.

- First, your participation in this interview is completely voluntary.
- If you decide not to participate, it will not affect you in any way.
- If there is any question you would rather not answer, just tell me and I will skip it.
- Most sessions take about 55 minutes or as long as you have.
- You can stop the session at any time, or we can reschedule the remainder of the session for another time.

We consider this discussion to be confidential. Your participation is confidential in the sense that your name will not be used in any reports or articles.

- We would like you to read this Informed Consent Form from Virginia Tech.
- Do you have any questions about this form or about our study?
- If you agree to proceed, please sign and date the form.
- Also, please note that we would like to record this conversation, but we need your consent in order to do so. You must indicate your agreement, or non-agreement, with audio taping on the consent form.

If the participant does not sign the form or chooses to leave before starting the interview: thank you very much for your time and willingness to hear about our work.

If the participant signs the form: thank you for signing this form. Please remember that this is a voluntary interview, which you may leave at any time.

I am turning the tape recorder on now. Just for our records, do I have your permission to tape this conversation?

Background Information

This session will be more of a conversation rather than a series of questions. In this second interview, we would like to hear your stories about your work experiences. Stories such as yours, that tell us what went well and what could have gone better will help us to understand how improvements can be made. As you tell your story, please do not use the real names of people included in your stories.

Essentially, I will be facilitating a discussion, but you as a group will do most of the talking. Some ground rules for the session:

- Everyone will have a chance to speak

- You are encouraged to add on to the contributions of others. However, please do not interrupt someone when they are speaking.
- Do not criticize the thoughts of others

I'll be asking you to share your stories/experiences with themes directed at IOM quality aims. As a guideline, we're looking for stories like you would tell friends/family when they ask "how was work today?" (i.e., fairly detailed but within HIPAA guidelines). As part of my dissertation these stories will be used by industrial design students to inspire new products/designs that address unmet nursing needs.

Do you have any questions about the study?
May we continue?

Before we get started, please tell me about your experience working here. In other words, please tell me "your story".

[Prompt those who have not contributed by asking the question again directly to them. (e.g., "[PARTICIPANT NAME], please tell me about your experience working here."]

How would you re-write this story? For example, walk me through how your work experience should be in an ideal world.

[Prompt those who have not contributed by asking the question again directly to them. (e.g., "[PARTICIPANT NAME], please walk me through how your work experience should be."]

Questions:
Safe (patient)

The first question is about patient safety. Please tell me that story about an experience you had where patient safety was an issue.

[Prompt those who have not contributed by asking the question again directly to them.]

How would you re-write this story? For example, walk me through how this experience would have been in an ideal world.

[Prompt those who have not contributed by asking the question again directly to them.]

Safe (practitioner)

The next question is about nurse safety (e.g., your own personal safety and/or the safety of your co-workers). Please tell me a story about an experience you had where practitioner safety was an issue.

[Prompt those who have not contributed by asking the question again directly to them.]

How would you re-write this story? For example, walk me through how this experience would have been in an ideal world.

[Prompt those who have not contributed by asking the question again directly to them.]

Effective

The next question is about effective care (e.g., barriers to providing effective care). Please tell me a story about an experience you had where care effectiveness was an issue.

[Prompt those who have not contributed by asking the question again directly to them.]

How would you re-write this story? For example, walk me through how this experience would have been in an ideal world.

[Prompt those who have not contributed by asking the question again directly to them.]

Patient-centered

The next question is about patient-centered care. Please tell me a story about an experience you had where patient-centered care was an issue.

[Prompt those who have not contributed by asking the question again directly to them.]

How would you re-write this story? For example, walk me through how this experience would have been in an ideal world.

[Prompt those who have not contributed by asking the question again directly to them.]

Timely (patient)

The next set of questions is about timeliness. Please tell me a story about an experience you had where patient timeliness (e.g., delay in care) was an issue.

[Prompt those who have not contributed by asking the question again directly to them.]

How would you re-write this story? For example, walk me through how this experience would have been in an ideal world.

[Prompt those who have not contributed by asking the question again directly to them.]

Timely (practitioner)

Please tell me a story about an experience you had where practitioner timeliness (e.g. where either you or a coworker experienced a delay in a task) was an issue.

[Prompt those who have not contributed by asking the question again directly to them.]

How would you re-write this story? For example, walk me through how this experience would have been in an ideal world.

[Prompt those who have not contributed by asking the question again directly to them.]

Efficient

The next set of questions is about efficiency. Please tell me a story about an experience you had where efficiency (e.g., waste in equipment, ideas, energy) was an issue.

[Prompt those who have not contributed by asking the question again directly to them.]

How would you re-write this story? For example, walk me through how this experience would have been in an ideal world.

[Prompt those who have not contributed by asking the question again directly to them.]

Equitable

The next set of questions is about equitable care. Please tell me a story about an experience you had where equitable care (e.g. barriers to providing quality care to everyone) was an issue.

[Prompt those who have not contributed by asking the question again directly to them.]

How would you re-write this story? For example, walk me through how this experience would have been in an ideal world.

[Prompt those who have not contributed by asking the question again directly to them.]

Close Interview

Is there anything else you would like us to know about your work experiences?

Thank you for taking the time to speak with me today.

A.5.4 Storytelling Session Script – Method GH

[Adapted from Shield et. al. (2005)]

Introduction

My name is [INTERVIEWER'S NAME], and I am a graduate student in [DEPARTMENT NAME] at Virginia Tech. The goal of today's storytelling session is to improve our understanding of healthcare worker's work environments and experiences so we can design products to meet your needs.

Informed consent

Before we begin, there are a couple of important things that I need to go over with you.

- First, your participation in this interview is completely voluntary.
- If you decide not to participate, it will not affect you in any way.
- If there is any question you would rather not answer, just tell me and I will skip it.
- Most sessions take about 55 minutes or as long as you have.
- You can stop the session at any time, or we can reschedule the remainder of the session for another time.

We consider this discussion to be confidential. Your participation is confidential in the sense that your name will not be used in any reports or articles.

- We would like you to read this Informed Consent Form from Virginia Tech.
- Do you have any questions about this form or about our study?
- If you agree to proceed, please sign and date the form.
- Also, please note that we would like to record this conversation, but we need your consent in order to do so. You must indicate your agreement, or non-agreement, with audio taping on the consent form.

If the participant does not sign the form or chooses to leave before starting the interview: thank you very much for your time and willingness to hear about our work.

If the participant signs the form: thank you for signing this form. Please remember that this is a voluntary interview, which you may leave at any time.

I am turning the tape recorder on now. Just for our records, do I have your permission to tape this conversation?

Background Information

This session will be more of a conversation rather than a series of questions. In this second interview, we would like to hear your stories about your work experiences. Stories such as yours, that tell us what went well and what could have gone better will help us to understand how improvements can be made. As you tell your story, please do not use the real names of people included in your stories.

Essentially, I will be facilitating a discussion, but you as a group will do most of the talking. Some ground rules for the session:

- Everyone will have a chance to speak

- You are encouraged to add on to the contributions of others. However, please do not interrupt someone when they are speaking.
- Do not criticize the thoughts of others

I'll be asking you to share your stories/experiences with themes directed at IOM quality aims. As a guideline, we're looking for stories like you would tell friends/family when they ask "how was work today?" (i.e., fairly detailed but within HIPAA guidelines). As part of my dissertation these stories will be used by industrial design students to inspire new products/designs that address unmet nursing needs.

Do you have any questions about the study?
May we continue?

Before we get started, please tell me about your experience working here. In other words, please tell me "your story".

[Prompt those who have not contributed by asking the question again directly to them. (e.g., "[PARTICIPANT NAME], please tell me about your experience working here."]

Questions:

Safe (patient)

The first question is about patient safety. Please tell me that story about an experience you had where patient safety was an issue.

[Prompt those who have not contributed by asking the question again directly to them.]

Safe (practitioner)

The next question is about nurse safety (e.g., your own personal safety and/or the safety of your co-workers). Please tell me a story about an experience you had where practitioner safety was an issue.

[Prompt those who have not contributed by asking the question again directly to them.]

Effective

The next question is about effective care (e.g., barriers to providing effective care). Please tell me a story about an experience you had where care effectiveness was an issue

[Prompt those who have not contributed by asking the question again directly to them.]

Patient-centered

The next question is about patient-centered care. Please tell me a story about an experience you had where patient-centered care was an issue.

[Prompt those who have not contributed by asking the question again directly to them.]

Timely (patient)

The next set of questions is about timeliness. Please tell me a story about an experience you had where patient timeliness (e.g., delay in care) was an issue.

[Prompt those who have not contributed by asking the question again directly to them.]

Timely (practitioner)

Please tell me a story about an experience you had where practitioner timeliness (e.g. where either you or a coworker experienced a delay in a task) was an issue.

[Prompt those who have not contributed by asking the question again directly to them.]

Efficient

The next set of questions is about efficiency. Please tell me a story about an experience you had where efficiency (e.g., waste in equipment, ideas, energy) was an issue.

[Prompt those who have not contributed by asking the question again directly to them.]

Equitable

The next set of questions is about equitable care. Please tell me a story about an experience you had where equitable care (e.g. barriers to providing quality care to everyone) was an issue.

[Prompt those who have not contributed by asking the question again directly to them.]

Close Interview

Is there anything else you would like us to know about your work experiences?

Thank you for taking the time to speak with me today.

A.6 Narrative Component Definitions & Examples

| Category | Required | Definition(s) | Example(s) |
|-------------|----------|------------------------------|--|
| Abstract | No | -summary | <ul style="list-style-type: none"> • And it's like they're all sick and backed up and stuff so I felt very unsafe because I felt like I needed to be in all 3 rooms at once. |
| Orientation | No | Contextual information | |
| | | Setting description | <ul style="list-style-type: none"> • We have a section of 4 patients usually • it's hard because we don't have sitters down here like somebody would sit with them like they might in the in-patient floors |
| | | Character description | <ul style="list-style-type: none"> • I had just gotten off of orientation and I was still brand new. • And they all ended up being ICU patients • I had a patient come in who was intoxicated • [The patient] had a foley in |
| | | Event background description | <ul style="list-style-type: none"> • I got 3 critical patients at once because you can't really tell the EMSes not to come in. • and it was the same situation where we didn't have enough nurses so I wasn't getting a lot of help, and so being a brand new nurse with that. • But you can't really restrain someone like that either because you're irritated that they just don't understand WHY they can't get up, WHY they are being restrained so it's making them more agitated and in the long run that can mess |

| | | | |
|----------------------------|------------|---|--|
| | | | <p>up.</p> <ul style="list-style-type: none"> • which is a tube that goes into the bladder and so to keep the foleys in you have to blow up a little balloon that is inside the bladder with 10ccs • ...you can use like chemical restraints or physical restraints – we couldn't chemically restrain [the patient] using sedative medication because of [the] levels [and organ function] |
| Complicating Action | YES | The "Plot" | |
| | | Temporal sequence of event(s) | <ul style="list-style-type: none"> • I saw [the patient] try to get up and walk and [the patient] was hooked to an IV and to the bag behind and you can't – that bag wasn't coming with [the patient]. |
| | | "Cause" in a "cause/effect" relationship | <ul style="list-style-type: none"> • So the EMSes come in • so [the patient] would try to get up |
| | | Conflict | <ul style="list-style-type: none"> • and [the patient] was ripping everything off and we needed [the patient] to be on the monitor, we needed [the patient] to keep [their] IV in. |
| Resolution | No | Result | |
| | | of temporal sequence of event(s) | |
| | | of conflict | <ul style="list-style-type: none"> • and I was worried that [the patient] was going to pull that out, pull out [the] IV... • and then I was worried because [the patient] was so big that the physical restraints would – |
| | | "Effect" in a "cause/effect" relationship | <ul style="list-style-type: none"> • so I felt like I was running my own little ICU in the back • and [the patient] kept almost plopping out of bed and falling so the charge nurse was like, "Sit down! Sit down!" and kind of reminding [the |

| | | | |
|------------|----|---|---|
| | | | patient] because [the patient] just wasn't getting it. |
| Evaluation | No | Why story told (i.e., indication of the "morale" of the story. | |
| | | Opinion of the events | <ul style="list-style-type: none"> • So you have to do a lot of things at once and if you get 3 in a row, back to back, it's really hard. |
| | | Reflection on the events | <ul style="list-style-type: none"> • I guess it was hard because the charge nurse at the time didn't know that all of my patients were that sick and those were the only beds that were open. • So that is something with patient safety that I felt that I was lacking and being a nurse I couldn't be their advocate because I couldn't be there for each of them • [This story] doesn't have much to do with equipment, just with the patient load. I guess it can kind of go with patient load like Participant_3 was talking about. |
| Coda | No | Statement that returns the speaker to the present day – indicates end of the storytelling | <ul style="list-style-type: none"> • So yeah, that was patient safety |

A.7 Narrative Analysis Instructions

A.7.1 General Guidelines for Narrative Analysis

- **ALWAYS WORK OFF OF YOUR DATA STICK AND PASSWORD PROTECT ALL FILES.**
- You will be working with 2 files. The original STORY transcript and the new NARRATIVE file that you create. Be sure to use the template “Narrative_Template_update.docx” to create the narrative file. Save the narrative file as the name of the story file with the appendix “n_yourname”. (e.g., “GHH_P2P3_n_Kim)
- Use the highlighted headings in the original document to locate the stories. Note that some story information may be outside of these demarcations. For example, a participant may add additional information later in the transcript referring back to that story.
- Note that you do not have to analyze the first part of the transcript where the researcher asks the participant to describe “their story”. That section is just to get the rapport going with the participants. You’ll be starting at the “habitual patient story” section.
- When analyzing a HABITUAL story, always identify the complicating action first and the abstract last
- Always copy FULL sentences first and then break the sentences up during upcoming iterations.
- If a component category doesn’t have anything in it (e.g. Coda), put N/A in place of the line number and sentence text
- ***Analysis is an Iterative Process***
 - Each story will take between 1-n iterations to complete. See Step #2 in the Narrative Analysis Steps (page 2 of this document) for detailed instructions for how to manage the iterations.
 - See file “Example_Iterations.docx” for a detailed example of each iteration for the analysis of the first story in GHH_P2P3. I added comments to explain why I made certain decisions. You should not comment every decision except for the “tricky statements” (see the Steps for Narrative Analysis below for more information)

- ***Analysis is an Interpretive Process***

- You may find that many story statements could fit into multiple narrative categories. It is your job to select the BEST category for the statement. When in doubt, to determine the BEST category refer to the:
 - narrative component definitions & example statements
 - exemplar analysis file

If you are still unsure that you have categorized the statement into the best category, highlight the text of the statement in RED (i.e., change the font color to red). Also add a “comment” using Words commenting feature explaining the rationale for categorizing the statement in that way.

- Be consistent in your judgments as possible.
 - Maintain a file entitled n_decisions_yourname (e.g., n_decisions_Kim.doc) that details the decisions & rationale for “tricky” statements. This should help you make decisions for other similar “tricky” statements. This file will come in handy when you meet with the judge to discuss discrepancies with the other data coder.

A.7.2 Steps for Narrative Analysis – HABITUAL STORY:

The purpose of narrative analysis of the habitual story is data categorization/organization & data reduction. Unlike a hypothetical narrative, it is important that the final habitual narrative reads well from top to bottom.

1. Add line numbers to the STORY file, if they are not there already.
2. Start the narrative iterations
 - a. First iteration:
 - i. Read the complete story (i.e., the text between the highlighted story demarcations)
 - ii. Identify the complicating action(s) first since all narratives MUST have a complicating action.
 - iii. Always copy FULL sentences from the original story file first
 - b. Second iteration
 - i. Break up the complicating action statements that contain more than one narrative component (Follow instructions below in c.i)
 - ii. After you have finished analyzing the complicating actions(s), continue analysis for all other narrative components EXCEPT THE ABSTRACT (e.g., orientation, resolution, evaluation, coda) starting at the first sentence in the story and working your way down to the story end.
 - iii. Always copy FULL sentences from the original story file first
 - c. Third iteration – ^{nth} iteration
 - i. Break up full sentences that contain more than one narrative component (e.g., orientation & complicating action)
 - a. Identify phrase breaks in the sentence, such as “AND”, “-“, “...“, “SO”
 - b. Does the phrase belong in a different narrative category?
 - i. YES?
 1. Copy phrase to new category
 2. Use line number of phrase to place sequentially within the new category
 - ii. NO?
 1. Move on to next phrase

- d. $n^{\text{th}}-1$ iteration
 - i. **To determine when to stop analyzing a story:**
 - 1. Read through from orientation -> evaluation.
 - a. Does the narrative make sense?
 - i. Yes?
 - 1. Move onto next iteration
 - ii. No?
 - 1. Double check the complicating action
- e. n^{th} (i.e., LAST) iteration
 - i. locate abstract, if there is one
 - 1. Looking for single sentence or phrase that:
 - a. Summarizes the story &
 - b. Can be removed from the narrative and have the narrative retain it's meaning
 - ii. Double check abstract, if there is one
 - a. Does the narrative retain the same meaning as the original story in the transcript?
 - b. If there is an abstract
 - i. Does the narrative match the abstract?
 - ii. Does the abstract summarize the story?
 - 2. YES for all questions?
 - a. Double check narrative line numbers to ensure they match with story line numbers.
 - b. Story analysis complete. Move on to next story in transcript.
 - 3. NO for "Does the narrative make sense?"
 - a. Double check the complicating action
 - 4. NO for "Does the narrative retain the same meaning as the original story in the transcript?"
 - a. Double check the complicating action
 - b. Double check the ordering of the orientation & complicating action. Some things may need to be swapped around.
 - 5. NO for abstract questions:
 - a. Try swapping the abstract & the complicating action(s)
 - b. Try moving the abstract to the complicating action(s)
 - c. If a&b doesn't solve it, move the abstract back to where it was. The narrative doesn't have an abstract.
- iii. **NARRATIVE ANALYSIS FOR HABITUAL STORY FINISHED**
 - 1. Move onto next story in transcript

A.7.3 Steps for Narrative Analysis – HYPOTHETICAL STORY:

The purpose of the narrative analysis of the hypothetical story is to match up statements made about the “real world” with statements made about the “ideal”. This process results in the creation of a hypothetical narrative. Note that unlike a habitual narrative, it is not important that the indented statements (i.e., the hypothetical statements) read well from top to bottom. The final result should look more like a bulleted list of “ideal” things that address the problem in the real world.

1. Start the narrative iterations
 - a. First iteration:
 - i. Read the complete hypothetical story (i.e., the text between the highlighted story demarcations)
 - ii. Copy & paste the full HABITUAL narrative that you just created. This will act as the framework for the HYPOTHETICAL narrative.
 - iii. Delete all information in the Abstract, Evaluation and Coda. Keep the information in the Orientation, Complicating Action & Resolution.
 - b. Second iteration
 - i. The point of the second iteration is to match up full sentences from story transcript to lines in the HABITUAL narrative. You are basically matching up identified problems with the stated “ideal”. If a story sentence doesn’t match an item in the narrative, add it to the Evaluation section and indent, bold & italicize the text so that it is prominent (see example). Start at the first sentence in the hypothetical story and work your way down to the story end. Indent ideal story sentences under the narrative phrase it matches (see example analysis file)
 - ii. Always copy FULL sentences from the original story file first
 - c. Third iteration – ^{nth} iteration
 - i. Break up full sentences that match more than one line in the narrative
 - a. Identify phrase breaks in the sentence, such as “AND”, “-“, “...“, “SO”
 - b. Does the phrase match another habitual narrative statement?
 - i. YES?
 1. Copy phrase below the habitual phrase
 2. Use line number of phrase to place sequentially below the habitual phrase
 - ii. NO?
 1. Move on to next phrase

- d. $n^{\text{th}}-1$ iteration
 - i. To determine when to stop analyzing a story:**
 - 1. Read through from orientation -> evaluation.
 - a. Do all of the “IDEAL:” statements match the original habitual narrative phrases?
 - i. Yes?
 - 1. Move onto next iteration
 - ii. No?
 - 1. Double check orientation vs. complicating action.
- e. n^{th} (i.e., LAST) iteration
 - i. locate abstract, if there is one
 - 1. Looking for single sentence or phrase that:
 - a. Summarizes the story &
 - b. Can be removed from the narrative and have the narrative retain it’s meaning
 - ii. Double check abstract, if there is one
 - a. Does the narrative retain the same meaning as the original story in the transcript?
 - b. If there is an abstract
 - i. Does the narrative match the abstract?
 - ii. Does the abstract summarize the story?
 - 2. YES for all questions?
 - a. Double check narrative line numbers to ensure they match with story line numbers.
 - b. Story analysis complete. Move on to next story in transcript.
 - 3. NO for abstract questions:
 - a. If a&b doesn’t solve it, move the abstract back to where it was. They narrative doesn’t have an abstract.
 - iii. NARRATIVE ANALYSIS FOR HYPOTHETICAL STORY FINISHED

Move onto next story in transcript

A.8 Example Analysis

HABITUAL STEP 1: Read Habitual Story*.

1 Patient safety? Oh, man. I'll tell you about my worst day ever. I can actually
2 remember the date, it was so bad. Man, was it bad. It was so bad that if I say,
3 "My worst day" everyone in the ER knows what I am talking about. Anyway,
4 there's an annual festival here that brings in a lot of out-of-towners. There's a
5 lot of drinking at the festival. Let me ask you a question -what do you think you
6 get when you add more people and more drinking to a town like this? You
7 guessed it, a lot more people stumbling into the ER. And this isn't news to
8 anybody. It's just how it works. So I'm working the last night of my 3 night
9 shift and I'm already sort of burned out because the last 2 nights weren't any
10 walk in the park, either. [Laughing] So I come in and I can tell from the day
11 shift that they have had it rough so I already kind of have an inkling that this
12 night is going to be a whopper. I start off by taking over 2 patients from day
13 shift, which is no big deal – I can handle that. And then I don't know what happened,
14 but it was like somebody let the gates open and we just got a flood of patients
15 and I found myself with 4 bed patients and 3 hallway patients. Luckily, no one
16 was critical, but I was still like, "I can't wait for this shift to end". Keep in mind
17 that 3 ER patients are usually PLENTY to keep a nurse busy. 7 is just insane!
18 But what can you do? You can't turn people away at the ER and the
19 administration is so focused on productivity numbers and how quick we get
20 patients from the front to the back. And to make it worse my patients were
21 spread all over the place. I had 2 in the back rooms where you can't see
22 anything, 2 in rooms by the nurses' station and 3 in the hallway. And one of the
23 patients was a frequent flier with dementia and I was worried about not being
24 able to keep a visual on [him/her]. Usually I would put this patient by the
25 nurses' station for someone to watch, but everyone was just so bogged down
26 with patients that there wasn't anyone available just to watch [him/her].
27 Luckily, nothing happened that night patient-safety-wise, but that was just
28 sheer luck. We just didn't have enough staff to handle that influx of patients.
29 Man, what a night. I felt like I was running a marathon the whole time running
30 from patient-to-patient. When I left I never felt like coming back again. I am
31 dreading the festival this year. I hope I'm not working that night. [Laughing].
32 We were really understaffed that day so I don't understand why administration
33 doesn't give us the staffing we need.

*fictional story

HABITUAL STEP 2: Identify Complicating Action

Step 2-1: Process Full Sentences

| | | Decision Rationale |
|----------------------------|---|---|
| Abstract | | |
| Orientation | | |
| Complicating Action | | |
| 13 | And then I don't know what happened, but it was like somebody let the gates open and we just got a flood of patients and I found myself with 4 bed patients and 3 hallway patients. | Cause & Effect: Cause: We just got a flood of patients Effect: I found myself with 4 bed patients and 3 hallway patients |
| Resolution | | |
| Evaluation | | |

Step 2-2: Process Phrases

| | | |
|----------------------------|--|-------------------------------------|
| Abstract | | |
| Orientation | | |
| 13 | And then I don't know what happened, but it was like somebody let the gates open and | Event background description |
| Complicating Action | | |
| 14 | we just got a flood of patients | Cause |
| Resolution | | |
| 15 | and I found myself with 4 bed patients and 3 hallway patients. | Effect |
| Evaluation | | |

HABITUAL STEP 3: Process remaining full sentences line-by-line

| | | |
|--------------------|--|--|
| Abstract | | |
| Orientation | | |

| | | |
|----------------------------|--|-------------------------------------|
| 4 | There's an annual festival here that brings in a lot of out-of-towners. There's a lot of drinking at the festival. Let me ask you a question -what do you think you get when you add more people and more drinking to a town like this? You guessed it, a lot more people stumbling into the ER. And this isn't news to anybody. It's just how it works. So I'm working the last night of my 3 night shift and I'm already sort of burned out because the last 2 nights weren't any walk in the park, either. | <i>Event background description</i> |
| 10 | So I come in and I can tell from the day shift that they have had it rough so I already kind of have an inkling that this night is going to be a whopper. I start off by taking over 2 patients from day shift, which is no big deal– I can handle that. And then I don't know what happened, but it was like somebody let the gates open and | <i>Event background description</i> |
| 32 | We were really understaffed that day so I don't understand why administration doesn't give us the staffing we need. | <i>Event background description</i> |
| Complicating Action | | |
| 14 | we just got a flood of patients | <i>Cause</i> |
| Resolution | | |
| 15 | and I found myself with 4 bed patients and 3 hallway patients. | <i>Effect</i> |
| 20 | And to make it worse my patients were spread all over the place. I had 2 in the back rooms where you can't see anything, 2 in rooms by the nurses' station and 3 in the hallway. And one of the patients was a frequent flier with dementia and I was worried about not being able to keep a visual on [him/her]. Usually I would put this patient by the nurses' station for someone to watch, but everyone was just so bogged down with patients that there wasn't anyone available just to watch [him/her]. | <i>Effect</i> |
| Evaluation | | |
| 1 | I'll tell you about my worst day ever. I can actually remember the date, it was so bad. | <i>Reflection</i> |
| 2 | It was so bad that if I say, "My worst day" everyone in the ER knows what I am talking about. | <i>Reflection</i> |
| 15 | Luckily, no one was critical, but I was still like, "I can't wait for this shift to end". Keep in mind that 3 ER patients are usually PLENTY to keep a nurse busy. 7 is just | <i>Reflection</i> |

| | | |
|----|--|--------------------------|
| | insane! But what can you do? You can't turn people away at the ER and the administration is so focused on productivity numbers and how quick we get patients from the front to the back. | |
| 27 | Luckily, nothing happened that night patient-safety-wise, but that was just sheer luck. We just didn't have enough staff to handle that influx of patients. | <i>Reflection</i> |
| 29 | I felt like I was running a marathon the whole time running from patient-to-patient. When I left I never felt like coming back again. I am dreading the festival this year. I hope I'm not working that night. | <i>Reflection</i> |

HABITUAL STEP 4: Process phrase level

| | | |
|----------------------------|--|-------------------------------------|
| Abstract | | |
| Orientation | | |
| 4 | There's an annual festival here that brings in a lot of out-of-towners. There's a lot of drinking at the festival. Let me ask you a question -what do you think you get when you add more people and more drinking to a town like this? You guessed it, a lot more people stumbling into the ER. And this isn't news to anybody. It's just how it works. So I'm working the last night of my 3 night shift and I'm already sort of burned out because the last 2 nights weren't any walk in the park, either. | <i>Event background description</i> |
| 10 | So I come in and I can tell from the day shift that they have had it rough so I already kind of have an inkling that this night is going to be a whopper. I start off by taking over 2 patients from day shift, which is no big deal - I can handle that. And then I don't know what happened, but it was like somebody let the gates open | <i>Event background description</i> |
| 32 | We were really understaffed that day | <i>Event background description</i> |
| Complicating Action | | |
| 14 | and we just got a flood of patients | <i>Cause</i> |
| Resolution | | |
| 15 | and I found myself with 4 bed patients and 3 hallway patients. | <i>Effect</i> |
| 20 | And to make it worse my patients were spread all over the place. I had 2 in the back rooms where you can't see anything, 2 in rooms by the nurses' station and 3 in the hallway. And one of the patients was a frequent flier with dementia and I was worried about not being able to keep a visual on [him/her]. Usually I would put this patient by the nurses' station for someone to watch, but everyone was just so bogged down with patients that there wasn't anyone available just to watch [him/her]. | <i>Effect</i> |
| Evaluation | | |
| 1 | I'll tell you about my worst day ever. I can actually remember the date, it was so bad. | <i>Reflection</i> |
| 2 | It was so bad that if I say, "My worst day" everyone in the ER knows what I am | <i>Reflection</i> |

| | | |
|----|---|-------------------|
| | talking about. | |
| 15 | Luckily, no one was critical, but I was still like, “I can’t wait for this shift to end”. Keep in mind that 3 ER patients are usually PLENTY to keep a nurse busy. 7 is just insane! But what can you do? You can’t turn people away at the ER and the administration is so focused on productivity numbers and how quick we get patients from the front to the back. | <i>Reflection</i> |
| 27 | Luckily, nothing happened that night patient-safety-wise, but that was just sheer luck. We just didn’t have enough staff to handle that influx of patients. | <i>Reflection</i> |
| 29 | I felt like I was running a marathon the whole time running from patient-to-patient. When I left I never felt like coming back again. I am dreading the festival this year. I hope I’m not working that night. | <i>Reflection</i> |
| 32 | I don’t understand why administration doesn’t give us the staffing we need. | <i>Reflection</i> |

HABITUAL STEP 5: IDENTIFY ABSTRACT, IF APPLICABLE

| | | |
|----------------------------|--|-------------------------------------|
| Abstract | | |
| 1 | My worst day ever. | <i>Summary</i> |
| Orientation | | |
| 4 | There's an annual festival here that brings in a lot of out-of-towners. There's a lot of drinking at the festival. Let me ask you a question -what do you think you get when you add more people and more drinking to a town like this? You guessed it, a lot more people stumbling into the ER. And this isn't news to anybody. It's just how it works. So I'm working the last night of my 3 night shift and I'm already sort of burned out because the last 2 nights weren't any walk in the park, either. | <i>Event background description</i> |
| 10 | So I come in and I can tell from the day shift that they have had it rough so I already kind of have an inkling that this night is going to be a whopper. I start off by taking over 2 patients from day shift, which is no big deal - I can handle that. And then I don't know what happened, but it was like somebody let the gates open | <i>Event background description</i> |
| 32 | We were really understaffed that day | <i>Event background description</i> |
| Complicating Action | | |
| 14 | and we just got a flood of patients | <i>Cause</i> |
| Resolution | | |
| 15 | and I found myself with 4 bed patients and 3 hallway patients. | <i>Effect</i> |
| 20 | And to make it worse my patients were spread all over the place. I had 2 in the back rooms where you can't see anything, 2 in rooms by the nurses' station and 3 in the hallway. And one of the patients was a frequent flier with dementia and I was worried about not being able to keep a visual on [him/her]. Usually I would put this patient by the nurses' station for someone to watch, but everyone was just so bogged down with patients that there wasn't anyone available just to watch [him/her]. | <i>Effect</i> |
| Evaluation | | |
| 1 | I can actually remember the date, it was so bad. | <i>Reflection</i> |
| 2 | It was so bad that if I say, "My worst day" everyone in the ER knows what I am | <i>Reflection</i> |

| | | |
|----|---|-------------------|
| | talking about. | |
| 15 | Luckily, no one was critical, but I was still like, “I can’t wait for this shift to end”. Keep in mind that 3 ER patients are usually PLENTY to keep a nurse busy. 7 is just insane! But what can you do? You can’t turn people away at the ER and the administration is so focused on productivity numbers and how quick we get patients from the front to the back. | <i>Reflection</i> |
| 27 | Luckily, nothing happened that night patient-safety-wise, but that was just sheer luck. We just didn’t have enough staff to handle that influx of patients. | <i>Reflection</i> |
| 29 | I felt like I was running a marathon the whole time running from patient-to-patient. When I left I never felt like coming back again. I am dreading the festival this year. I hope I’m not working that night. | <i>Reflection</i> |
| 32 | I don’t understand why administration doesn’t give us the staffing we need. | <i>Reflection</i> |

HABITUAL STEP 6: RE-READ ORIGINAL STORY & NARRATIVE AND VALIDATE MEANING RETENTION.

Completed Habitual Narrative

Abstract

1 My worst day ever.

Orientation

4 There's an annual festival here that brings in a lot of out-of-towners. There's a lot of drinking at the festival. Let me ask you a question -what do you think you get when you add more people and more drinking to a town like this? You guessed it, a lot more people stumbling into the ER. And this isn't news to anybody. It's just how it works. So I'm working the last night of my 3 night shift and I'm already sort of burned out because the last 2 nights weren't any walk in the park, either.

10 So I come in and I can tell from the day shift that they have had it rough so I already kind of have an inkling that this night is going to be a whopper. I start off by taking over 2 patients from day shift, which is no big deal - I can handle that. And then I don't know what happened, but it was like somebody let the gates open

32 We were really understaffed that day

Complicating Action

14 and we just got a flood of patients

Resolution

15 and I found myself with 4 bed patients and 3 hallway patients.

20 And to make it worse my patients were spread all over the place. I had 2 in the back rooms where you can't see anything, 2 in rooms by the nurses' station and 3 in the hallway. And one of the patients was a frequent flier with dementia and I was worried about not being able to keep a visual on [him/her]. Usually I would put this patient by the nurses' station for someone to watch, but everyone was just so bogged down with patients that there wasn't anyone available just to watch [him/her].

Evaluation

1 I can actually remember the date, it was so bad.

- 2 It was so bad that if I say, “My worst day” everyone in the ER knows what I am talking about.
- 15 Luckily, no one was critical, but I was still like, “I can’t wait for this shift to end”. Keep in mind that 3 ER patients are usually PLENTY to keep a nurse busy. 7 is just insane! But what can you do? You can’t turn people away at the ER and the administration is so focused on productivity numbers and how quick we get patients from the front to the back
- 27 Luckily, nothing happened that night patient-safety-wise, but that was just sheer luck. We just didn’t have enough staff to handle that influx of patients.
- 29 I felt like I was running a marathon the whole time running from patient-to-patient. When I left I never felt like coming back again. I am dreading the festival this year. I hope I’m not working that night.
- 32 I don’t understand why administration doesn’t give us the staffing we need.

HYPOTHETICAL STEP 1: Read Hypothetical Story

1 In an ideal world? Like that exists. [Laughing]. First off, the festival isn't a new thing and we should
2 know that we need more staffing that day. We have limited staffing, but they know we can't turn
3 anybody away in the ER so better management of patient intake is necessary too. Don't just send
4 everybody back to make productivity numbers. Anyway ideally weeks before the festival when
5 they are determining staffing schedules, the administration would go, "hey, hold on a minute. Isn't
6 the festival day usually a disaster in the ER?" [Laughing]. "Let's schedule more bodies so that we
7 have enough people to handle the influx of patients that happens every year". And better yet, it
8 would be great to prepare in advance for things that we know will be coming in. I know they have
9 data for that. We keep data on everything. It seems to me that we have a lot of possible alcohol
10 poisonings so in an ideal world we'd have the suction carts fully stocked and ready to go for those
11 hall patients. But even with extra staffing it can still get overloaded. I think it would have been
12 better that day if I didn't have to run around so much just to access my 7 patients. I could have
13 handled them a lot better if they were at least in the same proximity. And if they can't be in the
14 same general area, I need some way to check on patient's statuses without having to run in there all
15 the time. Like some sort of tablet thing that kept me updated on the go. It could send me patients
16 vitals and things like that. That way I wouldn't have to worry so much and stress myself out. It
17 also doesn't help the patients to see how stressed out we are. So ideally, I'd like patients to see cool,
18 calm, & collected nurses who are able to conquer the world! [Laughing] We have that at the nurses'
19 station, but in frantic times no one is manning the nurses' station. We're all on the go. So basically,
20 in my ideal world we'd have more staff and a better way to keep an eye on our patients.

HYPOTHETICAL STEP 2: Use Orientation, CA & Resolution from habitual narrative to start hypothetical framework

| | |
|----------------------------|--|
| Abstract | |
| Orientation | |
| 4 | There's an annual festival here that brings in a lot of out-of-towners. There's a lot of drinking at the festival. Let me ask you a question -what do you think you get when you add more people and more drinking to a town like this? You guessed it, a lot more people stumbling into the ER. And this isn't news to anybody. It's just how it works. So I'm working the last night of my 3 night shift and I'm already sort of burned out because the last 2 nights weren't any walk in the park, either. |
| 10 | So I come in and I can tell from the day shift that they have had it rough so I already kind of have an inkling that this night is going to be a whopper. I start off by taking over 2 patients from day shift, which is no big deal - I can handle that. And then I don't know what happened, but it was like somebody let the gates open |
| 32 | We were really understaffed that day |
| Complicating Action | |
| 14 | and we just got a flood of patients |
| Resolution | |
| 15 | and I found myself with 4 bed patients and 3 hallway patients. |
| 20 | And to make it worse my patients were spread all over the place. I had 2 in the back rooms where you can't see anything, 2 in rooms by the nurses' station and 3 in the hallway. And one of the patients was a frequent flier with dementia and I was worried about not being able to keep a visual on [him/her]. Usually I would put this patient by the nurses' station for someone to watch, but everyone was just so bogged down with patients that there wasn't anyone available just to watch [him/her]. |
| Evaluation | |

HYPOTHETICAL STEP 3: Categorize hypothetical sentences

| Abstract | | | Decision Rationale |
|--------------------|---|--|-----------------------------|
| Orientation | | | |
| 4 | There's an annual festival here that brings in a lot of out-of-towners. There's a lot of drinking at the festival. Let me ask you a question -what do you think you get when you add more people and more drinking to a town like this? You guessed it, a lot more people stumbling into the ER. And this isn't news to anybody. It's just how it works. So I'm working the last night of my 3 night shift and I'm already sort of burned out because the last 2 nights weren't any walk in the park, either. | | |
| 10 | So I come in and I can tell from the day shift that they have had it rough so I already kind of have an inkling that this night is going to be a whopper. I start off by taking over 2 patients from day shift, which is no big deal - I can handle that. And then I don't know what happened, but it was like somebody let the gates open | | |
| 32 | We were really understaffed that day | | |
| | 1 | <i>First off, the festival isn't a new thing and we should know that we need more staffing that day. We have limited staffing, but they know we can't turn anybody away in the ER so better management of patient intake is necessary too.</i> | <i>Alternative staffing</i> |
| | 4 | <i>Anyway, ideally weeks before the festival when they are determining staffing schedules, the administration</i> | <i>Alternative staffing</i> |

| | | | |
|----------------------------|--|---|---------------------------------------|
| | | <i>would go, “hey, hold on a minute. Isn’t the festival day usually a disaster in the ER?” [Laughing]. “Let’s schedule more bodies so that we have enough people to handle the influx of patients that happens every year”.</i> | |
| Complicating Action | | | |
| 14 | and we just got a flood of patients | | |
| | 3 | <i>Don’t just send everybody back to make productivity numbers.</i> | <i>Alternative patient flow</i> |
| Resolution | | | |
| 15 | and I found myself with 4 bed patients and 3 hallway patients. | | |
| 20 | And to make it worse my patients were spread all over the place. I had 2 in the back rooms where you can’t see anything, 2 in rooms by the nurses’ station and 3 in the hallway. And one of the patients was a frequent flier with dementia and I was worried about not being able to keep a visual on [him/her]. Usually I would put this patient by the nurses’ station for someone to watch, but everyone was just so bogged down with patients that there wasn’t anyone available just to watch [him/her]. | | |
| | 7 | <i>And better yet, it would be great to prepare in advance for things that we know will be coming in. I know they have data for that. We keep data on everything. It seems to me that we have a lot of possible alcohol poisonings so in an ideal world we’d have the suction carts fully stocked and ready to go for</i> | <i>Alternative supply preparation</i> |

| | | | |
|-------------------|---|---|---------------------------------------|
| | | <i>those hall patients.</i> | |
| | <i>11</i> | <i>I think it would have been better that day if I didn't have to run around so much just to access my 7 patients. I could have handled them a lot better if they were at least in the same proximity. And if they can't be in the same general area, I need some way to check on patient's statuses without having to run in there all the time. Like some sort of tablet thing that kept me updated on the go. It could send me patients' vitals and things like that. That way I wouldn't have to worry so much and stress myself out.</i> | <i>Alternative patient management</i> |
| | <i>18</i> | <i>We have that at the nurses' station, but in frantic times no one is manning the nurses' station. We're all on the go.</i> | |
| Evaluation | | | |
| 11 | <i>But even with extra staffing it can still get overloaded.</i> | | <i>Reflection</i> |
| 16 | <i>It also doesn't help the patients to see how stressed out we are. So ideally, I'd like patients to see cool, calm, & collected nurses who are able to conquer the world!</i> | | <i>Reflection</i> |
| 19 | <i>So basically, in my ideal world we'd have more staff and a better way to keep an eye on our patients.</i> | | <i>Reflection</i> |

HYPOTHETICAL STEP 4: PROCESS PHRASES

| Abstract | | | Decision Rationale |
|--------------------|---|--|--------------------|
| Orientation | | | |
| 4 | There's an annual festival here that brings in a lot of out-of-towners. There's a lot of drinking at the festival. Let me ask you a question -what do you think you get when you add more people and more drinking to a town like this? You guessed it, a lot more people stumbling into the ER. And this isn't news to anybody. It's just how it works. So I'm working the last night of my 3 night shift and I'm already sort of burned out because the last 2 nights weren't any walk in the park, either. | | |
| 10 | So I come in and I can tell from the day shift that they have had it rough so I already kind of have an inkling that this night is going to be a whopper. I start off by taking over 2 patients from day shift, which is no big deal - I can handle that. And then I don't know what happened, but it was like somebody let the gates open | | |
| 32 | We were really understaffed that day | | |
| 1 | | <i>First off, the festival isn't a new thing and we should know that we need more staffing that day. We have limited staffing, but they know we can't turn anybody away in the ER</i> | |
| 4 | | <i>Anyway, ideally weeks before the festival when they are determining staffing schedules, the administration would go, "hey, hold on a minute. Isn't the festival day usually a disaster in the</i> | |

| | | | |
|----------------------------|--|---|--|
| | | <i>ER?” [Laughing]. “Let’s schedule more bodies so that we have enough people to handle the influx of patients that happens every year”.</i> | |
| Complicating Action | | | |
| 14 | and we just got a flood of patients | | |
| | 3 | <i>Don’t just send everybody back to make productivity numbers.</i> | |
| | 3 | <i>Better management of patient intake is necessary too.</i> | <i>Alternative way to handle flood of patients</i> |
| Resolution | | | |
| 15 | and I found myself with 4 bed patients and 3 hallway patients. | | |
| 20 | And to make it worse my patients were spread all over the place. I had 2 in the back rooms where you can’t see anything, 2 in rooms by the nurses’ station and 3 in the hallway. And one of the patients was a frequent flier with dementia and I was worried about not being able to keep a visual on [him/her]. Usually I would put this patient by the nurses’ station for someone to watch, but everyone was just so bogged down with patients that there wasn’t anyone available just to watch [him/her]. | | |
| | 7 | <i>And better yet, it would be great to prepare in advance for things that we know will be coming in. I know they have data for that. We keep data on everything. It seems to me that we have a lot of possible alcohol poisonings so in an ideal world we’d have the suction</i> | |

| | | | |
|-------------------|---|---|--|
| | | <i>carts fully stocked and ready to go for those hall patients.</i> | |
| | 11 | <i>I think it would have been better that day if I didn't have to run around so much just to access my 7 patients. I could have handled them a lot better if they were at least in the same proximity. And if they can't be in the same general area, I need some way to check on patient's statuses without having to run in there all the time. Like some sort of tablet thing that kept me updated on the go. It could send me patients' vitals and things like that. That way I wouldn't have to worry so much and stress myself out.</i> | |
| | 18 | <i>We have that at the nurses' station, but in frantic times no one is manning the nurses' station. We're all on the go.</i> | |
| Evaluation | | | |
| 11 | <i>But even with extra staffing it can still get overloaded.</i> | | |
| 16 | <i>It also doesn't help the patients to see how stressed out we are. So ideally, I'd like patients to see cool, calm, & collected nurses who are able to conquer the world!</i> | | |
| 19 | <i>So basically, in my ideal world we'd have more staff and a better way to keep an eye on our patients.</i> | | |

HYPOTHETICAL STEP 5: IDENTIFY ABSTRACT, IF APPLICABLE

| Abstract | | | Decision Rationale |
|--------------------|---|---|---------------------------|
| | 19 | <i>In my ideal world we'd have more staff and a better way to keep an eye on our patients.</i> | <i>Summary</i> |
| Orientation | | | |
| 4 | There's an annual festival here that brings in a lot of out-of-towners. There's a lot of drinking at the festival. Let me ask you a question -what do you think you get when you add more people and more drinking to a town like this? You guessed it, a lot more people stumbling into the ER. And this isn't news to anybody. It's just how it works. So I'm working the last night of my 3 night shift and I'm already sort of burned out because the last 2 nights weren't any walk in the park, either. | | |
| 10 | So I come in and I can tell from the day shift that they have had it rough so I already kind of have an inkling that this night is going to be a whopper. I start off by taking over 2 patients from day shift, which is no big deal - I can handle that. And then I don't know what happened, but it was like somebody let the gates open | | |
| 32 | We were really understaffed that day | | |
| | 1 | <i>First off, the festival isn't a new thing and we should know that we need more staffing that day. We have limited staffing, but they know we can't turn anybody away in the ER</i> | |
| | 4 | <i>Anyway, ideally weeks before the festival when they are determining</i> | |

| | | | |
|----------------------------|--|--|--|
| | | <i>staffing schedules, the administration would go, “hey, hold on a minute. Isn’t the festival day usually a disaster in the ER?” [Laughing]. “Let’s schedule more bodies so that we have enough people to handle the influx of patients that happens every year”.</i> | |
| Complicating Action | | | |
| 14 | and we just got a flood of patients | | |
| | 3 | <i>Don’t just send everybody back to make productivity numbers.</i> | |
| | 3 | <i>Better management of patient intake is necessary too.</i> | <i>Alternative way to handle flood of patients</i> |
| Resolution | | | |
| 15 | and I found myself with 4 bed patients and 3 hallway patients. | | |
| 20 | And to make it worse my patients were spread all over the place. I had 2 in the back rooms where you can’t see anything, 2 in rooms by the nurses’ station and 3 in the hallway. And one of the patients was a frequent flier with dementia and I was worried about not being able to keep a visual on [him/her]. Usually I would put this patient by the nurses’ station for someone to watch, but everyone was just so bogged down with patients that there wasn’t anyone available just to watch [him/her]. | | |
| | 7 | <i>And better yet, it would be great to prepare in advance for things that we know will be coming in. I know they have data for that. We keep data on</i> | |

| | | | |
|-------------------|---|---|--|
| | | <i>everything. It seems to me that we have a lot of possible alcohol poisonings so in an ideal world we'd have the suction carts fully stocked and ready to go for those hall patients.</i> | |
| | 11 | <i>I think it would have been better that day if I didn't have to run around so much just to access my 7 patients. I could have handled them a lot better if they were at least in the same proximity. And if they can't be in the same general area, I need some way to check on patient's statuses without having to run in there all the time. Like some sort of tablet thing that kept me updated on the go. It could send me patients' vitals and things like that. That way I wouldn't have to worry so much and stress myself out.</i> | |
| | 18 | <i>We have that at the nurses' station, but in frantic times no one is manning the nurses' station. We're all on the go.</i> | |
| Evaluation | | | |
| 11 | <i>But even with extra staffing it can still get overloaded.</i> | | |
| 16 | <i>It also doesn't help the patients to see how stressed out we are. So ideally, I'd like patients to see cool, calm, & collected nurses who are able to conquer the world!</i> | | |

HYPOTHETICAL STEP 6: RE-READ ORIGINAL STORY & NARRATIVE AND VALIDATE MEANING RETENTION.
Completed Hypothetical Narrative

Abstract

19 *In my ideal world we'd have more staff and a better way to keep an eye on our patients.*

Orientation

4 There's an annual festival here that brings in a lot of out-of-towners. There's a lot of drinking at the festival. Let me ask you a question -what do you think you get when you add more people and more drinking to a town like this? You guessed it, a lot more people stumbling into the ER. And this isn't news to anybody. It's just how it works. So I'm working the last night of my 3 night shift and I'm already sort of burned out because the last 2 nights weren't any walk in the park, either.

10 So I come in and I can tell from the day shift that they have had it rough so I already kind of have an inkling that this night is going to be a whopper. I start off by taking over 2 patients from day shift, which is no big deal - I can handle that. And then I don't know what happened, but it was like somebody let the gates open

32 We were really understaffed that day

1 *First off, the festival isn't a new thing and we should know that we need more staffing that day. We have limited staffing, but they know we can't turn anybody away in the ER*

4 *Anyway, ideally weeks before the festival when they are determining staffing schedules, the administration would go, "hey, hold on a minute. Isn't the festival day usually a disaster in the ER?" [Laughing]. "Let's schedule more bodies so that we have enough people to handle the influx of patients that happens every year".*

Complicating Action

14 and we just got a flood of patients

3 *Don't just send everybody back to make productivity numbers.*

3 *Better management of patient intake is necessary too.*

Resolution

15 and I found myself with 4 bed patients and 3 hallway patients.

20 And to make it worse my patients were spread all over the place. I had 2 in the back rooms where you can't see anything, 2 in rooms by the nurses' station and 3 in the hallway. And one of the patients was a frequent flier with dementia and I was worried about not being able to keep a visual on [him/her]. Usually I would put this patient by the nurses' station for someone to watch, but everyone was just so bogged down with patients that there wasn't anyone available just to watch [him/her].

7 *And better yet, it would be great to prepare in advance for things that we know will be coming in. I know they have data for that. We keep data on everything. It seems to me that we have a lot of possible alcohol poisonings so in an ideal world we'd have the suction carts fully stocked and ready to go for those hall patients.*

11 *I think it would have been better that day if I didn't have to run around so much just to access my 7 patients. I could have handled them a lot better if they were at least in the same proximity. And if they can't be in the same general area, I need some way to check on patient's statuses without having to run in there all the time. Like some sort of tablet thing that kept me updated on the go. It could send me patients' vitals and things like that. That way I wouldn't have to worry so much and stress myself out.*

18 *We have that at the nurses' station, but in frantic times no one is manning the nurses' station. We're all on the go.*

Evaluation

11 *But even with extra staffing it can still get overloaded.*

16 *It also doesn't help the patients to see how stressed out we are. So ideally, I'd like patients to see cool, calm, & collected nurses who are able to conquer the world!*

A.9 Narrative Analysis Template

Abstract

XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX
XXXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX

Orientation

XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX
XXXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX

XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX
XXXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX
XXXXXXXXXXXX

Complicating Action

XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX
XXXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX

XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX
XXXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX

Resolution

XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX
XXXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX

XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX
XXXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX

Evaluation

XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX
XXXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX

XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX
XXXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX

A.10 Judge Reconciliation Instructions

GENERAL INFO:

You will be working with the following files , which are available on Scholar, during each reconciliation meeting. Keep all 3 of these files open and display them on the LUCID monitor:

- **Merged Results:** Frameworks for each narrative that contain ONLY the agreed upon statements. This is your working document. You will copy your decisions here, resulting in a final agreed-upon narrative.
- **Decisions to be Made :** Highlights the coder disagreements for each narrative. These are the decisions that you need to make
- **Original Transcript File:** The group will refer back to the original transcript while making decisions

FOR EACH NARRATIVE:

Step 1: Read the participant's response in the original transcript file (e.g., IH_P13.doc)

Step 2: Start with first narrative in the Decisions File (e.g., Decisions_File.doc) & follow instructions to:

1. Agree on the complicating action
2. Categorize disagreement phrases considering the agreed upon complicating action
 - a. Designate decision in Decisions File noting the team members who agreed and leaving off team members who disagreed. REMEMBER – as a judge you have final decision making authority.
 - b. Copy phrases into the agreed upon category in the Merged file (e.g., IH_P13_Merged.doc)
3. After all decisions have been made, double-check each statement in the completed narrative.
 - a. Re-categorize phrases as appropriate
 - b. Designate changes in the Decision File
4. Re-read narrative
 - a. Does it make sense?
 - i. i.e., Would the reader know references to “they”, etc..
 - b. Does it retain the intent of the original story?
 - i. If not, re-categorize statements until it does.

A.11 Reconciliation Template – Fictional Example

Abstract

Orientation

- 4 There's an annual festival here that brings in a lot of out-of-towners. There's a lot of drinking at the festival.
- 7 And this isn't news to anybody. It's just how it works. So I'm working the last night of my 3 night shift and I'm already sort of burned out because the last 2 nights weren't any walk in the park, either.
- 32 We were really understaffed that day

Complicating Action

- 14 and we just got a flood of patients

Resolution

- 15 and I found myself with 4 bed patients and 3 hallway patients.
- 20 And to make it worse my patients were spread all over the place. I had 2 in the back rooms where you can't see anything, 2 in rooms by the nurses' station and 3 in the hallway. And one of the patients was a frequent flier with dementia and I was worried about not being able to keep a visual on [him/her]. Usually I would put this patient by the nurses' station for someone to watch, but everyone was just so bogged down with patients that there wasn't anyone available just to watch [him/her].

Evaluation

- 1 I can actually remember the date, it was so bad.
- 15 Luckily, no one was critical, but I was still like, "I can't wait for this shift to end". Keep in mind that 3 ER patients are usually PLENTY to keep a nurse busy. 7 is just insane! But what can you do? You can't turn people away at the ER and the administration is so focused on productivity numbers and how quick we get patients from the front to the back
- 27 Luckily, nothing happened that night patient-safety-wise, but that was just sheer luck. We just didn't have enough staff to handle that influx of patients.
- 29 I felt like I was running a marathon the whole time running from patient-to-patient. When I left I never felt like coming back again. I am dreading the festival this year. I hope I'm not working that night.
- 32 I don't understand why administration doesn't give us the staffing we need.

A.12 Judge decisions to be made during reconciliation meeting – Fictional Example

1 [HABITUAL – PATIENT SAFETY STORY]

1. WHAT IS THE COMPLICATING ACTION?

14 and we just got a flood of patients

OR

10 So I come in and I can tell from the day shift that they have had it rough so I already kind of have an inkling that this night is going to be a whopper. I start off by taking over 2 patients from day shift, which is no big deal - I can handle that. And then I don't know what happened, but it was like somebody let the gates open

14 and we just got a flood of patients

OR OTHER?

2. CONSIDERING THIS COMPLICATING ACTION, WHERE SHOULD OTHER PHRASES BE CATEGORIZED?

| LINE | PHRASE | CATEGORIZATION | DECISION |
|------|--|---|-----------|
| 1 | My worst day ever. | Abstract – Coder 1 Orientation – Coder 2 | A - ALL |
| 5 | Let me ask you a question – what do you think you get when you add more people and more drinking to a town like this? You guessed it, a lot more people stumbling into the ER. | Orientation – Coder 2 Evaluation – Coder 1 | O - JUDGE |
| 10 | So I come in and I can tell from the day shift that they have had it rough so I already kind of have an inkling that this night is going to be a whopper. I start off by taking over 2 patients from day shift, which is no big deal - I can handle that. And then I don't know what happened, but it was like somebody let the gates open | Orientation – Coder 2 CA – Coder1 | CA - ALL |

3. DOUBLE CHECK EACH STATEMENT IN THE AGREED UPON NARRATIVE. IS IT CATEGORIZED IN THE APPROPRIATE SPOT? IF YOU SUSPECT NOT, BRING IT UP FOR DEBATE & DESIGNATE DECISION HERE:

| LINE | PHRASE | CATEGORIZATION | DECISION |
|------|--------|----------------|----------|
| | | | |

4. RE-READ NARRATIVE TOGETHER. DOES IT MAKE SENSE? DOES IT RETAIN THE INTENT OF THE ORIGINAL STORY?

A.13 SAS Code for Inter-coder Agreement

```
proc freq;  
tables rater1*rater2 / agree;  
test kappa;  
run;
```

Team A – Before Reconciliation

The FREQ Procedure

Statistics for Table of RATER1 by RATER2

Test of Symmetry

| | |
|---------------|---------|
| Statistic (S) | 47.3437 |
| DF | 15 |
| Pr > S | <.0001 |

Simple Kappa Coefficient

| | |
|----------------------|--------|
| Kappa | 0.3314 |
| ASE | 0.0273 |
| 95% Lower Conf Limit | 0.2779 |
| 95% Upper Conf Limit | 0.3849 |

Test of H0: Kappa = 0

| | |
|-------------------|---------|
| ASE under H0 | 0.0223 |
| Z | 14.8778 |
| One-sided Pr > Z | <.0001 |
| Two-sided Pr > Z | <.0001 |

Weighted Kappa Coefficient

| | |
|----------------------|--------|
| Weighted Kappa | 0.3266 |
| ASE | 0.0329 |
| 95% Lower Conf Limit | 0.2621 |
| 95% Upper Conf Limit | 0.3911 |

Sample Size = 614

Team A – After Reconciliation

The FREQ Procedure

Statistics for Table of RATER1 by RATER2

Test of Symmetry

| | |
|---------------|--------|
| Statistic (S) | 1.0000 |
| DF | 15 |
| Pr > S | 1.0000 |

Simple Kappa Coefficient

| | |
|----------------------|--------|
| Kappa | 0.9935 |
| ASE | 0.0037 |
| 95% Lower Conf Limit | 0.9862 |
| 95% Upper Conf Limit | 1.0000 |

Test of H0: Kappa = 0

| | |
|-------------------|---------|
| ASE under H0 | 0.0223 |
| Z | 44.6483 |
| One-sided Pr > Z | <.0001 |
| Two-sided Pr > Z | <.0001 |

Weighted Kappa Coefficient

| | |
|----------------------|--------|
| Weighted Kappa | 0.9956 |
| ASE | 0.0025 |
| 95% Lower Conf Limit | 0.9907 |
| 95% Upper Conf Limit | 1.0000 |

Sample Size = 615

Team B Before Reconciliation

The SAS System

15:1

The FREQ Procedure

Statistics for Table of RATER1 by RATER2

Test of Symmetry

| | |
|---------------|----------|
| Statistic (S) | 141.1404 |
| DF | 15 |
| Pr > S | <.0001 |

Simple Kappa Coefficient

| | |
|----------------------|--------|
| Kappa | 0.5370 |
| ASE | 0.0230 |
| 95% Lower Conf Limit | 0.4918 |
| 95% Upper Conf Limit | 0.5821 |

Test of H0: Kappa = 0

| | |
|-------------------|---------|
| ASE under H0 | 0.0191 |
| Z | 28.0675 |
| One-sided Pr > Z | <.0001 |
| Two-sided Pr > Z | <.0001 |

Weighted Kappa Coefficient

| | |
|----------------------|--------|
| Weighted Kappa | 0.5702 |
| ASE | 0.0261 |
| 95% Lower Conf Limit | 0.5190 |
| 95% Upper Conf Limit | 0.6214 |

Sample Size = 642

Team B after reconciliation

The FREQ Procedure

Statistics for Table of RATER1 by RATER2

Test of Symmetry

| | |
|---------------|----|
| Statistic (S) | . |
| DF | 15 |
| Pr > S | . |

Simple Kappa Coefficient

| | |
|----------------------|--------|
| Kappa | 1.0000 |
| ASE | 0.0000 |
| 95% Lower Conf Limit | 1.0000 |
| 95% Upper Conf Limit | 1.0000 |

Test of H0: Kappa = 0

| | |
|-------------------|---------|
| ASE under H0 | 0.0200 |
| Z | 50.0244 |
| One-sided Pr > Z | <.0001 |
| Two-sided Pr > Z | <.0001 |

Weighted Kappa Coefficient

| | |
|----------------------|--------|
| Weighted Kappa | 1.0000 |
| ASE | 0.0000 |
| 95% Lower Conf Limit | 1.0000 |
| 95% Upper Conf Limit | 1.0000 |

Sample Size = 642

Team C before reconciliation

Simple Kappa Coefficient

| | |
|----------------------|--------|
| Kappa | 0.4681 |
| ASE | 0.0207 |
| 95% Lower Conf Limit | 0.4275 |
| 95% Upper Conf Limit | 0.5087 |

Test of H0: Kappa = 0

| | |
|-------------------|---------|
| ASE under H0 | 0.0178 |
| Z | 26.2333 |
| One-sided Pr > Z | <.0001 |
| Two-sided Pr > Z | <.0001 |

Weighted Kappa Coefficient

| | |
|----------------------|--------|
| Weighted Kappa | 0.5994 |
| ASE | 0.0216 |
| 95% Lower Conf Limit | 0.5570 |
| 95% Upper Conf Limit | 0.6418 |

Sample Size = 873

Team C after reconciliation

Statistics for Table of RATER1 by RATER2

Test of Symmetry

| | |
|---------------|---------|
| Statistic (S) | 11.0000 |
| DF | 15 |
| Pr > S | 0.7526 |

Simple Kappa Coefficient

| | |
|----------------------|--------|
| Kappa | 0.9833 |
| ASE | 0.0050 |
| 95% Lower Conf Limit | 0.9736 |
| 95% Upper Conf Limit | 0.9931 |

Test of H0: Kappa = 0

| | |
|-------------------|---------|
| ASE under H0 | 0.0181 |
| Z | 54.2406 |
| One-sided Pr > Z | <.0001 |
| Two-sided Pr > Z | <.0001 |

Weighted Kappa Coefficient

| | |
|----------------------|--------|
| Weighted Kappa | 0.9836 |
| ASE | 0.0049 |
| 95% Lower Conf Limit | 0.9739 |
| 95% Upper Conf Limit | 0.9932 |

Sample Size = 874

A.14 SAS Code for Session duration

```
proc glimmix plots=all;
title "SESSION TIME MODEL";
class setting;
model SESSION_TIME_MIN= setting;
lsmeans setting / adjust=tukey;
run;
```

Type III Tests of Fixed Effects

| Effect | Num DF | Den DF | F Value | Pr > F |
|-------------------|-----------|-----------|---------|--------|
| SETTING | 1 | 18 | 10.26 | 0.0049 |
| QUESTIONS | 1 | 18 | 1.65 | 0.2146 |
| SETTING*QUESTIONS | 1 | 18 | 3.77 | 0.0681 |

SETTING Least Squares Means

| SETTING | Estimate | Standard Error | DF | t Value | Pr > t |
|---------|----------|-------------------|----|---------|---------|
| 0 | 48.2219 | 3.9930 | 18 | 12.08 | <.0001 |
| 1 | 72.7167 | 6.5206 | 18 | 11.15 | <.0001 |

Differences of SETTING Least Squares Means Adjustment for Multiple Comparisons: Tukey-Kramer

| SETTING | _SETTING | Estimate | Standard Error | DF | t Value | Pr > t | Adj P |
|---------|----------|----------|-------------------|----|---------|---------|--------|
| 0 | 1 | -24.4948 | 8.0145 | 20 | -3.06 | 0.0062 | 0.0062 |

A.15 SAS Code for Total Narratives

```
proc glimmix plots=all;
title "TOTAL STORY QUANTITY DIFFERENCES BETWEEN GROUPS?";
class setting questions time;
model TOTAL_STORIES = setting questions time / dist=POISSON link=log;
lsmeans setting questions time / adjust=tukey;
run;
```

Fit Statistics

| | |
|--------------------------|--------|
| -2 Log Likelihood | 142.80 |
| AIC (smaller is better) | 152.80 |
| AICC (smaller is better) | 156.55 |
| BIC (smaller is better) | 158.25 |
| CAIC (smaller is better) | 163.25 |
| HQIC (smaller is better) | 154.08 |
| Pearson Chi-Square | 31.65 |
| Pearson Chi-Square / DF | 1.86 |

Type III Tests of Fixed Effects

| Effect | Num DF | Den DF | F Value | Pr > F |
|-----------|--------|--------|---------|--------|
| SETTING | 1 | 17 | 25.07 | 0.0001 |
| QUESTIONS | 1 | 17 | 11.94 | 0.0030 |
| TIME | 2 | 17 | 9.10 | 0.0021 |

SETTING Least Squares Means

| SETTING | Estimate | Standard Error | DF | t Value | Pr > t |
|---------|----------|----------------|----|---------|---------|
| 0 | 3.0906 | 0.05549 | 17 | 55.69 | <.0001 |
| 1 | 3.5300 | 0.06971 | 17 | 50.64 | <.0001 |

SETTING Least Squares Means

| SETTING | Estimate | Standard Error | DF | t Value | Pr > t |
|---------|----------|----------------|----|---------|---------|
| 0 | 3.0906 | 0.05549 | 17 | 55.69 | <.0001 |
| 1 | 3.5300 | 0.06971 | 17 | 50.64 | <.0001 |

Differences of SETTING Least Squares Means Adjustment for Multiple Comparisons: Tukey-Kramer

| SETTING | _SETTING | Estimate | Standard Error | DF | t Value | Pr > t | Adj P |
|---------|----------|----------|----------------|----|---------|---------|--------|
| 0 | 1 | -0.4394 | 0.08777 | 17 | -5.01 | 0.0001 | 0.0001 |

The GLIMMIX Procedure

QUESTIONS Least Squares Means

| QUESTIONS | Estimate | Standard Error | DF | t Value | Pr > t |
|-----------|----------|----------------|----|---------|---------|
| 0 | 3.4561 | 0.05753 | 17 | 60.07 | <.0001 |
| 1 | 3.1644 | 0.06590 | 17 | 48.02 | <.0001 |

Differences of QUESTIONS Least Squares Means
Adjustment for Multiple Comparisons: Tukey-Kramer

| QUESTIONS | _QUESTIONS | Estimate | Standard Error | DF | t Value | Pr > t | Adj P |
|-----------|------------|----------|----------------|----|---------|---------|--------|
| 0 | 1 | 0.2918 | 0.08444 | 17 | 3.46 | 0.0030 | 0.0030 |

TIME Least Squares Means

| TIME | Estimate | Standard Error | DF | t Value | Pr > t |
|------|----------|----------------|----|---------|---------|
| 1 | 3.5468 | 0.07119 | 17 | 49.82 | <.0001 |
| 2 | 3.3233 | 0.06642 | 17 | 50.03 | <.0001 |
| 3 | 3.0607 | 0.09054 | 17 | 33.80 | <.0001 |

Differences of TIME Least Squares Means
Adjustment for Multiple Comparisons: Tukey-Kramer

| TIME | _TIME | Estimate | Standard Error | DF | t Value | Pr > t | Adj P |
|------|-------|----------|----------------|----|---------|---------|--------|
| 1 | 2 | 0.2235 | 0.09587 | 17 | 2.33 | 0.0323 | 0.0783 |
| 1 | 3 | 0.4861 | 0.1146 | 17 | 4.24 | 0.0005 | 0.0015 |
| 2 | 3 | 0.2626 | 0.1110 | 17 | 2.37 | 0.0301 | 0.0734 |

A.16 SAS Code for Habitual Stories

```
proc glimmix plots=all;
title "HABITUAL STORY DIFFERENCES BETWEEN GROUPS?";
class setting time questions;
model H_STORIES_TOTAL = setting time questions / dist=POISSON link=log;
lsmeans setting time questions/ adjust=tukey;
run;
```

Fit Statistics

| | |
|--------------------------|--------|
| -2 Log Likelihood | 126.99 |
| AIC (smaller is better) | 136.99 |
| AICC (smaller is better) | 140.74 |
| BIC (smaller is better) | 142.45 |
| CAIC (smaller is better) | 147.45 |
| HQIC (smaller is better) | 138.28 |
| Pearson Chi-Square | 21.74 |
| Pearson Chi-Square / DF | 1.28 |

Type III Tests of Fixed Effects

| Effect | Num DF | Den DF | F Value | Pr > F |
|-----------|-----------|-----------|---------|--------|
| SETTING | 1 | 17 | 13.42 | 0.0019 |
| TIME | 2 | 17 | 7.83 | 0.0039 |
| QUESTIONS | 1 | 17 | 5.42 | 0.0325 |

SETTING Least Squares Means

| SETTING | Estimate | Standard Error | DF | t Value | Pr > t |
|---------|----------|-------------------|----|---------|---------|
| 0 | 2.8612 | 0.06225 | 17 | 45.96 | <.0001 |
| 1 | 3.2308 | 0.08095 | 17 | 39.91 | <.0001 |

SETTING Least Squares Means

| SETTING | Estimate | Standard Error | DF | t Value | Pr > t |
|---------|----------|-------------------|----|---------|---------|
| 0 | 2.8612 | 0.06225 | 17 | 45.96 | <.0001 |
| 1 | 3.2308 | 0.08095 | 17 | 39.91 | <.0001 |

Differences of SETTING Least Squares Means Adjustment for Multiple Comparisons: Tukey-Kramer

| SETTING | _SETTING | Estimate | Standard Error | DF | t Value | Pr > t | Adj P |
|---------|----------|----------|-------------------|----|---------|---------|--------|
| 0 | 1 | -0.3696 | 0.1009 | 17 | -3.66 | 0.0019 | 0.0019 |

QUESTIONS Least Squares Means

| QUESTIONS | Estimate | Standard Error | DF | t Value | Pr > t |
|-----------|----------|----------------|----|---------|---------|
| 0 | 2.9344 | 0.07400 | 17 | 39.65 | <.0001 |
| 1 | 3.1576 | 0.06675 | 17 | 47.30 | <.0001 |

Differences of QUESTIONS Least Squares Means
Adjustment for Multiple Comparisons: Tukey-Kramer

| QUESTIONS | _QUESTIONS | Estimate | Standard Error | DF | t Value | Pr > t | Adj P |
|-----------|------------|----------|----------------|----|---------|---------|--------|
| 0 | 1 | -0.2231 | 0.09583 | 17 | -2.33 | 0.0325 | 0.0325 |

| TIME | Estimate | Standard Error | DF | t Value | Pr > t |
|------|----------|----------------|----|---------|---------|
| 1 | 3.3041 | 0.08039 | 17 | 41.10 | <.0001 |
| 2 | 3.0321 | 0.07667 | 17 | 39.55 | <.0001 |
| 3 | 2.8018 | 0.1031 | 17 | 27.19 | <.0001 |

Differences of TIME Least Squares Means
Adjustment for Multiple Comparisons: Tukey-Kramer

| TIME | _TIME | Estimate | Standard Error | DF | t Value | Pr > t | Adj P |
|------|-------|----------|----------------|----|---------|---------|--------|
| 1 | 2 | 0.2720 | 0.1091 | 17 | 2.49 | 0.0232 | 0.0575 |
| 1 | 3 | 0.5024 | 0.1300 | 17 | 3.86 | 0.0012 | 0.0034 |
| 2 | 3 | 0.2303 | 0.1267 | 17 | 1.82 | 0.0868 | 0.1938 |

A.17 SAS Code for Hypothetical Stories

```
proc glimmix plots=all;
title "HYPOTHETICAL STORY DIFFERENCES BETWEEN GROUPS?";
class setting;
model HH_STORIES_TOTAL = setting / dist=POISSON link=log;
lsmeans setting/ adjust=tukey;
run;
```

Fit Statistics

| | |
|--------------------------|-------|
| -2 Log Likelihood | 86.17 |
| AIC (smaller is better) | 90.17 |
| AICC (smaller is better) | 91.67 |
| BIC (smaller is better) | 90.97 |
| CAIC (smaller is better) | 92.97 |
| HQIC (smaller is better) | 89.67 |
| Pearson Chi-Square | 31.50 |
| Pearson Chi-Square / DF | 3.50 |

Type III Tests of Fixed Effects

| Effect | Num DF | Den DF | F Value | Pr > F |
|---------|-----------|-----------|---------|--------|
| SETTING | 1 | 9 | 13.32 | 0.0053 |

SETTING Least Squares Means

| SETTING | Estimate | Standard Error | DF | t Value | Pr > t |
|---------|----------|-------------------|----|---------|---------|
| 0 | 2.2644 | 0.1140 | 9 | 19.87 | <.0001 |
| 1 | 2.9087 | 0.1348 | 9 | 21.57 | <.0001 |

Differences of SETTING Least Squares Means Adjustment for Multiple Comparisons: Tukey-Kramer

| SETTING | _SETTING | Estimate | Standard Error | DF | t Value | Pr > t | Adj P |
|---------|----------|----------|-------------------|----|---------|---------|--------|
| 0 | 1 | -0.6444 | 0.1765 | 9 | -3.65 | 0.0053 | 0.0053 |

APPENDIX B. Phase 2 Documents

B.1 Thematic Analysis Instructions

THEMATIC ANALYSIS INSTRUCTIONS

BACKGROUND INFORMATION:

Thank you for your participation in this research study. Please read below for information to guide your analysis. Your assistance in this project consists of the following steps:

- 1) **Identify functional and usability needs in ER nurses' narratives using**
 - a. Atlas TI qualitative software
 - b. Grounded theory approach to thematic analysis (i.e., iterative analysis & cross comparisons between narratives)
 - c. Ontology for usability needs (Figure 1)
- 2) **Reconcile your coding results in a 2-hour weekly meeting with your assigned research team.** (i.e., meeting with other coder & coding judge)
- 3) **Export final results to Excel spreadsheet that can be used for later statistical analysis (Format TBD) for:**
 - a. Each transcript
 - b. Each research treatment (i.e., IH, GH, IHH, GHH). The title for each transcript contains the research treatment (e.g., the title GHH_P6P7.doc means treatment GHH with Participant6 and Participant7)

Your research involvement will result in the following deliverables:

- **A master Atlas TI file** that represents your reconciled (i.e., agreed upon) coding results. This file should be named `Thematic_Analysis_Agreed.hpr6` and should be:
 - saved on your assigned memory sticks
 - uploaded to the Scholar research site created for this phase of the project (TBD)
- **A master Excel spreadsheet** (Format TBD)

Some information about thematic analysis:

Thematic analysis is an iterative process. When you've completed the analysis for a particular transcript AND you have identified a new functional or usability need that you haven't seen before, you must go back to all previously coded transcripts and code for the new theme(s). For example, if on transcript #6, you discover a new functional need (eg, "nurse: chart blood pressure"), you must go back to all previously coded transcripts (1-5) to see if you can apply that functional need/code to any participant statements in those transcripts.

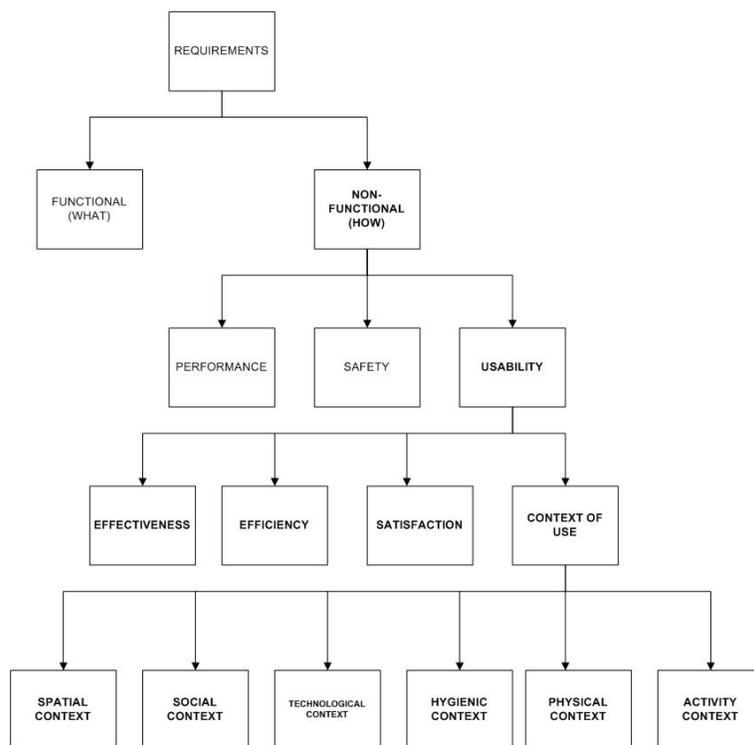
Thematic analysis is a subjective process, meaning there is NO right or wrong answer. Use your best judgment and work with your research team to reconcile the results during the weekly meeting.

While doing your analysis, consider this scenario:

You are a requirements engineer for a medical device company. Your company, which has already designed, manufactured, and marketed several successful products, is interested in identifying unmet needs in an Emergency Room (ER) setting. Following recommendations for

conducting user research as the first step of device development in ANSI/AAMI HE74:2001, the company conducted interviews with ER nurses’ at several hospital locations to “explore the problem space”. You have the transcripts of all of these sessions and your boss has asked you to identify functional and usability needs as the first step of analysis. You will use Atlas TI software, a qualitative research tool, to manage your results.

You will be coding several (~ 24) transcripts looking for functional and usability needs. The overall goal of your analysis is to identify user needs and associate them with existing requirements categories as shown below. **Note that for the purposes of this exercise, you are only looking for functional and usability needs.** So look over the definitions of requirements themes (at the end of the document) and keep these in you mind as you identify themes in the transcripts.



Ontology for user needs. Note you are only coding for functional & usability needs.

One way to view your analysis is that you are assigning user needs to “boxes”. For example, you are looking for any stated or implied user need that can fit into one or more of the following “boxes”:

Functional Needs

Usability Needs

- Efficiency needs
- Effectiveness needs
- Satisfaction needs
- Context-of-use needs
 - Spatial context needs
 - Social context needs
 - Technological context needs
 - Hygienic context needs
 - Physical context needs
 - Activity context needs

TO GET STARTED:

- Read over thematic analysis section from Gribch (handout)
- Familiarize yourself with the Atlas TI software.
 - Manual is available at <http://www.atlasti.com/downloads/atlman.pdf>
 - You will mainly be using the following Atlas TI functions:
 - Assign document (how you load a transcript into the project)
 - Open coding (right click on a sentence and then type the code in)
 - Code by list (choose an already existing code)
 - Categorize the user needs (Codes->Edit Families->Open Family Manager)
 - Code manager to view the codes (Codes->Code Manager)
- Review the provided examples below

Steps for Thematic Analysis of Narratives – Revised 08/31/11

For each narrative,

STEP 1: Read individual narrative

STEP 2: Identify Functional User Needs

1. Go line-by-line starting from the narrative beginning
2. Assign Code
 - If New Code ⇒ Create code following format below
 - If Existing Code ⇒ Reformat into following format below (i.e., promote code to functional format)
3. Categorize into “functional” family

DEF: Functional

| | |
|------------|--|
| | States the functional need – “the WHAT” |
| functional | <i>What</i> the worker or current/needed system needs to do The worker will _____ The system will _____ |

FORMAT for Functional Needs:

| | |
|----------------------|--|
| active verb + object | e.g., deliver blood e.g., protect staff e.g., protect patients e.g., seclude patients e.g., prevent missed steps |
|----------------------|--|

STEP 3: Identify Effectiveness & Efficiency User Needs

1. Go line-by-line starting from the narrative beginning
2. Assign Code that addresses HOW the identified functional need should be:
 - If New Code ⇒ Create code following format below
 - Otherwise ⇒ Re-use existing code
3. Categorize into families
 - For ALL functional code(s) created in Step 2 ⇒ Categorize into effectiveness and/or efficiency, if appropriate
 - For all codes created & reused in this Step 3 ⇒ Categorize into effectiveness and/or efficiency, if appropriate

DEF: Effectiveness & Efficiency

| | |
|---------------|---|
| | Describes the functional need – “the HOW” |
| effectiveness | Level of <u>accuracy</u> & <u>completeness</u> in which a user is able to satisfy the goals |
| efficiency | Amount of <u>resources</u> used to achieve goals |

FORMAT

| | |
|---|---|
| active verb + object + prepositional phrase | e.g., protect nurses <i>from physical attack</i> e.g. protect patients <i>from self-injury</i> |
| active verb + object + adverb | e.g., deliver blood <i>quickly</i> |

STEP 4: Identify Context-of-Use User Needs

1. Go line-by-line starting from the narrative beginning
2. Assign Code that addresses *in what context the functional need occurs*:
 If New Code ⇒ Create code following format below
 Otherwise ⇒ Re-use existing code
3. Categorize into families
 For previous codes created in Step 2-4 ⇒ Categorize into satisfaction, if appropriate
 For all codes created & reused in this Step 4 ⇒ Categorize into effectiveness and/or efficiency, if appropriate

DEF: activity, hygienic, physical, social, spatial, physical, technological context

| | |
|---------------|--|
| Activity | -distractions & other tasks that may interfere -surprise/startle effect -strain & stress -influence on the working environment (e.g., not able to hear patient over noise) -workload & fatigue |
| Hygienic | -cleanliness/ sterile conditions required -cleaning & waste disposal |
| Physical | -climate conditions (e.g., light, noise, temp) |
| Social | -organization -transition of care -who is around (e.g., children, family, etc....) -responsibility (e.g., shared vs. alone) |
| Spatial | -architecture -location: -outdoors -patient transport (e.g., airplane, ambulance, car) |
| Technological | -other technologies / devices involved |

FORMAT context

| | |
|-------------------------------|---|
| object + adjective | e.g., seclusion room unavailable |
| gerund + prepositional phrase | e.g., working with psych patients e.g., working with mental health evaluator e.g., working with EMS |
| gerund + adjective | e.g., working alone |

STEP 5: Identify Satisfaction Needs

1. Go line-by-line starting from the narrative beginning
2. Categorize into families

For ALL code(s) created in Step 2-4 ⇒ Categorize into satisfaction, if appropriate

DEF: satisfaction

| | |
|--------------|---|
| satisfaction | Perceived <u>comfort level</u> and <u>acceptability</u> while working towards goals |
|--------------|---|

EXAMPLE ANALYSIS

[Example redacted as the example provided to analysts contained ATLAS.ti screenshots of actual participant statements. The example has been redacted to preserve research site and participant confidentiality. See Appendix B.3 for example analysis of a fictional participant response.]

WORKING WITH ATLAS TI –

CODING THE DOCUMENT

-each transcript should be it's own Hermeneutic Unit (eg, separate project file)

STEP 1: OPEN HERMENEUTIC UNIT

STEP 2: LOAD THE TRANSCRIPT FILE (if not loaded already)

Document->Assign->Select file->Open

STEP 3: VIEW THE TRANSCRIPT FILE

Select the file in the dropdown within Atlas TI to view it. (the dropdown at the left-hand side of the screen)

STEP 4: READ & CODE:

- Read the full narrative before you identify functional and usability needs
- Analyze the narrative sequentially, line by line
 - NOTE: The smallest possible quotation for a code is a full sentence.
 - NOTE: When getting started you'll mainly use free codes (CTRL+SHIFT+O) but once you get a bunch of codes you can code by list (CTRL+SHIFT+L)
- Code your identified functional and usability needs
 - Assign the code
 - If a newly identified need:
 - Highlight the quotation (should be at least 1 sentence long) -> Codes->Coding->Open Coding ->type the code(s)
 - If an existing need that you've seen before in other narratives
 - Highlight the quotation (should be at least 1 sentence long) -> Codes->Coding->code by list ->select the code(s)
 - If it's a NEW user need or it's an EXISTING user need that supports categorization into another category (e.g., previously categorized in effectiveness, but this statement suggests it should be satisfaction as well).
 - Categorize the code
 - Highlight code with mouse/cursor->Codes->Edit Families->Assign families->choose the categories you think that excerpt fits into and click OK. You will only be able to see categories that haven't yet been assigned to that code.

STEP 5: RECONILIATION MEETING

- Instructions TBD

GO TO STEP 1 & REPEAT FOR ALL REMAINING TRANSCRIPTS

B.2 Reconciliation Judge Instructions

RECONCILIATION CHEAT SHEET – JUDGE

Prior to Reconciliation Meeting:

1. Download Atlas TI bundle from appropriate folder in Scholar (e.g., Reconciliation/Thurs 09-22)
2. Install the bundle on your own memory stick
 - a. Create new folder on memory stick
 - b. In Atlas TI, choose “Tools->Copy Bundle->Install Bundle”.
 - i. NOTE: Install the bundle into the new folder you just created on your memory stick
 - ii. Be sure to save this file. This will be the file that you use during the reconciliation meeting.
3. Download the Decisions file from appropriate folder in Scholar (e.g., Reconciliation/Thurs 09-22)
 - a. Save file to the folder you created above
 - b. This will be the file you use during the meeting to record the decisions.
4. In AtlasTI Look over the files that are to be reconciled (e.g. GHH_P6P7) and familiarize yourself with the codes

During Reconciliation Meeting

Possible Tasks

1. Merge Codes (i.e., when coders used different words to say the same thing)
 - a. In Atlas TI ->Codes->Code Manager->Highlight the desired code ->Right click ->Merge Codes ->Select code to merge into highlighted code
 - b. Make note of this change on the Decisions File
2. Rename Code
 - a. In Atlas TI ->Codes ->Code Manager->Double click the desired code to make the title editable
 - b. Make note of this change on the Decisions File
3. Categorize Code
 - a. In Atlas TI->Codes->Edit Families->Open Family Manager
 - b. Highlight desired category (e.g., activity context)
 - c. Highlight desired code in right hand column and click arrow to move it to the category
 - d. Make note of this change on the Decisions file

After Reconciliation Meeting

1. Upload completed Decisions file to Scholar
2. Bundle the revised Atlas TI file
 - a. In Atlas TI->Tools->Copy Bundle->Create Bundle (it should be a .acb file)
3. Upload Bundle to Scholar

B.3 Reconciliation Template

Step 1: Verify Merge & Rephrasing Decisions

[list of merges]

[list of rephrases]

Step 2: Verify Categories & Add Additional Categories for New Codes:

| <i>Coder1 Codes</i> | <i>Categories</i> |
|----------------------------|--------------------------|
| | |
| | |
| | |
| | |
| | |
| | |

| <i>Coder2 Codes</i> | <i>Categories</i> |
|----------------------------|--------------------------|
| | |
| | |
| | |
| | |
| | |
| | |

B.4 Example Thematic Analysis

Step 1. Read individual narrative

Abstract

1 My worst day ever.

Orientation

4 There's an annual festival here that brings in a lot of out-of-towners. There's a lot of drinking at the festival. Let me ask you a question -what do you think you get when you add more people and more drinking to a town like this? You guessed it, a lot more people stumbling into the ER. And this isn't news to anybody. It's just how it works. So I'm working the last night of my 3 night shift and I'm already sort of burned out because the last 2 nights weren't any walk in the park, either.

10 So I come in and I can tell from the day shift that they have had it rough so I already kind of have an inkling that this night is going to be a whopper. I start off by taking over 2 patients from day shift, which is no big deal - I can handle that. And then I don't know what happened, but it was like somebody let the gates open

32 We were really understaffed that day

Complicating Action

14 and we just got a flood of patients

Resolution

15 and I found myself with 4 bed patients and 3 hallway patients.

20 And to make it worse my patients were spread all over the place. I had 2 in the back rooms where you can't see anything, 2 in rooms by the nurses' station and 3 in the hallway. And one of the patients was a frequent flier with dementia and I was worried about not being able to keep a visual on [him/her]. Usually I would put this patient by the nurses' station for someone to watch, but everyone was just so bogged down with patients that there wasn't anyone available just to watch [him/her].

Evaluation

1 I can actually remember the date, it was so bad.

- 2 It was so bad that if I say, “My worst day” everyone in the ER knows what I am talking about.
- 15 Luckily, no one was critical, but I was still like, “I can’t wait for this shift to end”. Keep in mind that 3 ER patients are usually PLENTY to keep a nurse busy. 7 is just insane! But what can you do? You can’t turn people away at the ER and the administration is so focused on productivity numbers and how quick we get patients from the front to the back
- 27 Luckily, nothing happened that night patient-safety-wise, but that was just sheer luck. We just didn’t have enough staff to handle that influx of patients.
- 29 I felt like I was running a marathon the whole time running from patient-to-patient. When I left I never felt like coming back again. I am dreading the festival this year. I hope I’m not working that night.
- 32 I don’t understand why administration doesn’t give us the staffing we need.

Step 2: Identify functional user needs

Orientation

- 4 There's an annual festival here that brings in a lot of out-of-towners. There's a lot of drinking at the festival. Let me ask you a question -what do you think you get when you add more people and more drinking to a town like this? You guessed it, a lot more people stumbling into the ER. And this isn't news to anybody. It's just how it works. So I'm working the last night of my 3 night shift and I'm already sort of burned out because the last 2 nights weren't any walk in the park, either.
- 10 So I come in and I can tell from the day shift that they have had it rough so I already kind of have an inkling that this night is going to be a whopper. I start off by taking over 2 patients from day shift, which is no big deal - I can handle that. And then I don't know what happened, but it was like somebody let the gates open
- 32 We were really understaffed that day

Complicating Action

- 14 and we just got a flood of patients

Resolution

- 15 and I found myself with 4 bed patients and 3 hallway patients.
- 20 And to make it worse my patients were spread all over the place. I had 2 in the back rooms where you can't see anything, 2 in rooms by the nurses' station and 3 in the hallway. And one of the patients was a frequent flier with dementia and I was worried about not being able to keep a visual on [him/her]. Usually I would put this patient by the nurses' station for someone to watch, but everyone was just so bogged down with patients that there wasn't anyone available just to watch [him/her].

Evaluation

- 1 I can actually remember the date, it was so bad.
- 2 It was so bad that if I say, "My worst day" everyone in the ER knows what I am talking about.
- 15 Luckily, no one was critical, but I was still like, "I can't wait for this shift to end". Keep in mind that 3 ER patients are usually PLENTY to keep a nurse busy. 7 is just insane! But what can you do? You can't turn people away at the ER and the administration is so focused on productivity numbers and how quick we get patients from the front to the back
- 27 Luckily, nothing happened that night patient-safety-wise, but that was just sheer luck. We just didn't have enough staff to handle that influx of patients.
- 29 I felt like I was running a marathon the whole time running from patient-to-patient. When I left I never felt like coming back again. I am dreading the festival this year. I hope I'm not working that night.
- 32 I don't understand why administration doesn't give us the staffing we need.

-  assign patients
-  monitor patients
-  support nurses

-  support nurses

Iteration 2 Code List

| | | |
|--------------------------|--------------------------------------|---|
| <i>Functional</i> | The worker will: The system will: | assign patients monitor patients support nurses |
|--------------------------|--------------------------------------|---|

Step 3: Identify Effectiveness & Efficiency Needs

Orientation

- 4 There's an annual festival here that brings in a lot of out-of-towners. There's a lot of drinking at the festival. Let me ask you a question -what do you think you get when you add more people and more drinking to a town like this? You guessed it, a lot more people stumbling into the ER. And this isn't news to anybody. It's just how it works. So I'm working the last night of my 3 night shift and I'm already sort of burned out because the last 2 nights weren't any walk in the park, either.
- 10 So I come in and I can tell from the day shift that they have had it rough so I already kind of have an inkling that this night is going to be a whopper. I start off by taking over 2 patients from day shift, which is no big deal - I can handle that. And then I don't know what happened, but it was like somebody let the gates open
- 32 We were really understaffed that day

Complicating Action

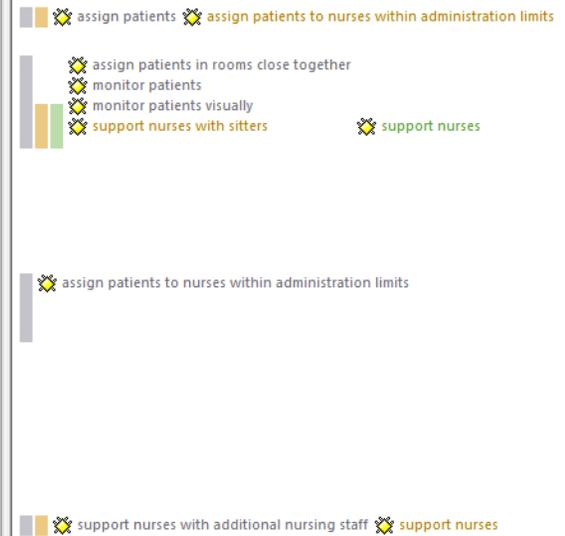
- 14 and we just got a flood of patients

Resolution

- 15 and I found myself with 4 bed patients and 3 hallway patients.
- 20 And to make it worse my patients were spread all over the place. I had 2 in the back rooms where you can't see anything, 2 in rooms by the nurses' station and 3 in the hallway. And one of the patients was a frequent flier with dementia and I was worried about not being able to keep a visual on [him/her]. Usually I would put this patient by the nurses' station for someone to watch, but everyone was just so bogged down with patients that there wasn't anyone available just to watch [him/her].

Evaluation

- 1 I can actually remember the date, it was so bad.
- 2 It was so bad that if I say, "My worst day" everyone in the ER knows what I am talking about.
- 15 Luckily, no one was critical, but I was still like, "I can't wait for this shift to end". Keep in mind that 3 ER patients are usually PLENTY to keep a nurse busy. 7 is just insane! But what can you do? You can't turn people away at the ER and the administration is so focused on productivity numbers and how quick we get patients from the front to the back
- 27 Luckily, nothing happened that night patient-safety-wise, but that was just sheer luck. We just didn't have enough staff to handle that influx of patients.
- 29 I felt like I was running a marathon the whole time running from patient-to-patient. When I left I never felt like coming back again. I am dreading the festival this year. I hope I'm not working that night.
- 32 I don't understand why administration doesn't give us the staffing we need.



Iteration 3 Code List:

| | | |
|-----------------------------|---|--|
| <i>Functional</i> | The worker will: The system will: | assign patients monitor patients support nurses |
| <i>Effectiveness</i> | Level of accuracy & completeness in which a user is able to satisfy the goals | assign patients to nurses within administration limits |
| <i>Efficiency</i> | Amount of resources used to achieve goals | monitor patients visually assign patients in room close together support nurses with sitters support nurses with additional nursing staff |

Step 4: Identify Context-of-Use Needs

Orientation

4 There's an annual festival here that brings in a lot of out-of-towners. There's a lot of drinking at the festival. Let me ask you a question -what do you think you get when you add more people and more drinking to a town like this? You guessed it, a lot more people stumbling into the ER. And this isn't news to anybody. It's just how it works. So I'm working the last night of my 3 night shift and I'm already sort of burned out because the last 2 nights weren't any walk in the park, either.

10 So I come in and I can tell from the day shift that they have had it rough so I already kind of have an inkling that this night is going to be a whopper. I start off by taking over 2 patients from day shift, which is no big deal - I can handle that. And then I don't know what happened, but it was like somebody let the gates open

32 We were really understaffed that day

Complicating Action

14 and we just got a flood of patients

Resolution

15 and I found myself with 4 bed patients and 3 hallway patients.

20 And to make it worse my patients were spread all over the place. I had 2 in the back rooms where you can't see anything, 2 in rooms by the nurses' station and 3 in the hallway. And one of the patients was a frequent flier with dementia and I was worried about not being able to keep a visual on [him/her]. Usually I would put this patient by the nurses' station for someone to watch, but everyone was just so bogged down with patients that there wasn't anyone available just to watch [him/her].

Evaluation

1 I can actually remember the date, it was so bad.

2 It was so bad that if I say, "My worst day" everyone in the ER knows what I am talking about.

15 Luckily, no one was critical, but I was still like, "I can't wait for this shift to end". Keep in mind that 3 ER patients are usually PLENTY to keep a nurse busy. 7 is just insane! But what can you do? You can't turn people away at the ER and the administration is so focused on productivity numbers and how quick we get patients from the front to the back

27 Luckily, nothing happened that night patient-safety-wise, but that was just sheer luck. We just didn't have enough staff to handle that influx of patients.

29 I felt like I was running a marathon the whole time running from patient-to-patient. When I

working with intoxicated patients

working with sudden influx of patients

working with multiple patients assign patients assign patients to nurses within administration limits

assign patients in rooms close together
monitor patients
monitor patients visually
working with mentally altered patients
support nurses

nurse station centrally located
support nurses with sitters
working alone

assign patients to nurses within administration limits working with non-critical patients

working with sudden influx of patients

staff physically stressed

Iteration 4 Code List

| | | |
|-------------------------------------|---|---|
| <i>Functional</i> | The worker will: The system will: | assign patients monitor patients support nurses |
| <i>Effectiveness</i> | Level of accuracy & completeness in which a user is able to satisfy the goals | assign patients to nurses within administration limits |
| <i>Efficiency</i> | Amount of resources used to achieve goals | monitor patients visually assign patients in room close together support nurses with sitters support nurses with additional nursing staff |
| <i>Activity context</i> | Distractions Tasks Surprise/startle effect Strain & stress Influence on the working environment Workload & fatigue | working with sudden influx of patients working with intoxicated patients working with multiple patients working with mentally altered patients working with non-critical patients |
| <i>Hygienic context</i> | Cleanliness / sterile conditions required Cleaning Waste disposal | n/a |
| <i>Physical context</i> | Climate conditions Light level Noise level | n/a |
| <i>Social context</i> | Organization Transition of care Who is round (e.g., children, family, etc....) Responsibility (e.g., shared vs. alone) | working alone |
| <i>Spatial context</i> | Architecture Locations Patient transport | nurses' station centrally located |
| <i>Technological context</i> | Other technologies / devices involved | n/a |

Step 5: Identify Satisfaction Needs

Iteration 5 Code List:

| | | |
|------------------------------|---|---|
| Functional | The worker will: The system will: | assign patients monitor patients support nurses |
| Effectiveness | Level of accuracy & completeness in which a user is able to satisfy the goals | assign patients to nurses within administration limits |
| Efficiency | Amount of resources used to achieve goals | monitor patients visually assign patients in room close together support nurses with sitters support nurses with additional nursing staff |
| Activity context | Distractions, Tasks Surprise/startle effect Strain & stress Influence on the working environment Workload & fatigue | working with sudden influx of patients working with intoxicated patients working with multiple patients working with mentally altered patients working with non-critical patients |
| Hygienic context | Cleanliness / sterile conditions required Cleaning, Waste disposal | n/a |
| Physical context | Climate conditions Light level, Noise level | n/a |
| Social context | Organization Transition of care Who is round (e.g., children, family, etc....) Responsibility (e.g., shared vs. alone) | working alone |
| Spatial context | Architecture Locations Patient transport | nurses' station centrally located |
| Technological context | Other technologies / devices involved | n/a |
| Satisfaction | Perceived comfort level and acceptability while working towards goals | assign patients to nurses within administration limits assign patients in room close together support nurses with additional nursing staff |

B.5 User Need List

B.5.1 All identified user needs

accomodate patients
accomodate patients of different acuity levels
accomodate patients of various ages
accomodate patients of various sizes
adapt resources appropriately
address patient needs
administer flu swab
admit patients
admit patients from holding area
admit patients quickly
admit patients through triage window
admit patients through triages readily
admit patients to beds
alert staff
alert staff of errors through feedback
alert staff of patient movement
alert staff to mobilize
allow patient decisions
answer phone calls
arriving by ambulance
arriving by car
assign nurse of specific gender appropriately
assign patients
assign patients in rooms close together
assign patients logically
assign patients to flex beds
assign staff efficiently
assign staff within physical proximity
attend to lab needs properly
bair huggers available
bedside toilets available
being new
being on call
blood bank computerized
blood labs available
bodily fluids exposed
calculate medicine amounts
change equipment
change equipment between patients
chart information
chart information digitally

chart information digitally automatically
chart information on paper (non-digitally)
chart information quickly
chart information verbally
chart information with admission orders
chart information with medication error report
chart information with reported pain level
classify patients
classify patients based on acuity
clean bodily fluids
close doors
collect urine samples
communicate information
communicate information (decision rationale) with staff
communicate information with accessible call system
communicate information with non-English speaking patient
communicate information with non-English speaking patient quickly
communicate information with the family
communicate information with the patient
communicate information with the patient after discharge
communicate order information between physicians and nurses
communicating poorly
computer system backed up
computer system functioning effectively
computer system working precautionarily
conduct communicable disease cultures
CT scanner outside of ER
defibrillate patients
deliver babies
deliver labs
deliver labs via vacuum tube
deliver oxygen
diagnose patients
diagnose patients correctly
discharge patients
distinguish equipment easily
distribute controlled drugs
do CPR
do medication reconciliations
do pelvic exam
do task efficiently
document vital signs
document vital signs quickly
doorways open
double check calculations
double check staff

draw blood
educate patients
educate staff
eliminate double documentation
equipment in trauma bay
ER areas separated
ER setup
explain home care
find equipment
find equipment easily
find equipment quickly
find staff
find staff quickly
fire nurse
focus attention appropriately
follow procedures
follow procedures correctly
give ABG
give out cab ticket
gurneys low to the ground
hang patient blood
ID patients
ID patients from 2 identifiers
identify allergies
insert foley
insert nasal gastric tube
interact with Medicaid
intervene crisis situation
keep equipment consistent throughout rooms
lab upstairs
label medications
label medications clearly
label samples
label samples clearly
lay out hospital
lay out hospital appropriately
lift item
lift item easily
lock doors
look up dosages
manage foleys
management corrects patient behavior
medicate patient
medicate patient by matching patient to medications
medicate patient correctly
medicate patient quickly

medicate patient with IV
medicate patient with medicine distributing armband
medicate patient with mentally altered status
medicate patients while tracking unadministered medications
medicate patients with similar names
monitor fetal heart rate
monitor lab work
monitor medications
monitor patient vitals
monitor patient vitals from pulse ox
monitor patient vitals wirelessly
monitor patients
monitor patients in suicide specific room
monitor patients on tracking boards
monitor patients through larger windows
monitor patients vitals quickly
notify staff
notify staff of new orders
nurse station centrally located
obtain consent
order medicine
order medicine accurately
order medicine digitally
order medicine verbally
order medicine with override
order medicine with override emergently
order medicines logically
order supplies
order x-rays
organize work
organize work appropriately
panic button available
patient bed available
patients in waiting room
patients mobile
patients nude
pharmacy upstairs
portable monitors available
prepare patient
prepare patient for surgery
prepare patient room
prepare staff
prepare staff physically
prescriptions online
present information
present information in multiple places

prevent missed steps
prevent patient theft
prioritize lab and lab results
protect patients
protect patients from "cookie cutter" care
protect patients from escape
protect patients from injury
protect patients from medication order errors
protect patients from mixups
protect patients from physical attack
protect patients from privacy invasions
protect patients from self-injury
protect patients from sharps
protect patients from unequal treatment
protect patients from unnecessary delays
protect staff
protect staff from contamination
protect staff from injuries during patient shocks
protect staff from physical attack
protect staff from self-injury
protect staff from sexual harassment
protect staff from sharps
protect staff from wet floors
provide bair hugger quickly
provide equipment in each room
provide home health
provide lab results
provide lab results quickly
provide medical records
provide medical records easily
provide medical supplies
provide medical supplies adequately
provide medical supplies portably
provide medication dosage
provide medication dosage appropriately
provide medication dosage readily
provide pet therapy
provide resources adequately
provide respiratory care
put in catheter
reassess triage patients
recycle equipment
reduce waste
request a court order
restrain patients
room organized well

rooms have enough space
run CT scan
scan blood bags
scan medications
scan medications sequentially
scan supplies
screen patients
screen patients for diseases
screen patients for drugs
screen patients for weapons
screen patients quickly
seclude patients
seclusion rooms available
secure supplies
sedate patients
send tests away to be read
serenity room available
staff stressed
start a saline lock
start EKGs
stitch up patient
stock medications
stock medications in correct area
support nurses
support nurses with additional nursing staff
support nurses with assistants
support nurses with backup computers
support nurses with heart attack teams
support nurses with patient transporters
support nurses with scribes
support nurses with tablets
take blood pressure
take body temperatures
technology is outdated
train new nurse
transfer patient care
transfer patient care to other hospital
transport patients
transport patients on gurneys
treat burns
treat patients repeatedly
triage patients
troubleshoot computer system
troubleshoot computer system easily
uncuff prisoners
use accudose machine

use computer system
use computer system easily
use CPOE
use EMAR scanning
use equipment
use equipment comfortably
use equipment easily
use equipment multi-dimensionally
use equipment safely
use internet
use Nighthawk
use paper charts
use pepper spray
use phone translator
use PICIS
use printer
use protocol
use protocol effectively
use pumps
use pumps effectively
use technology
use technology effectively
use tube system
ventilation adequate
waiting for doctor to see patient
wear gloves
workers in front of ER
working alone
working at an inner city hospital
working in an ambulance
working in an emotionally open environment
working in an isolation room
working in front of ER at night
working in ideal conditions
working in large hospitals
working in small hospitals
working together
working with abused patients
working with allergic reactions
working with angry patients
working with armed patients
working with asthmatic patients
working with automated software
working with cell phones
working with common problems
working with computers during triage

working with consulting physicians
working with counselor
working with critical patients
working with dead patients
working with deaf patients
working with disrespectful patients
working with doctors
working with ED techs
working with elderly people
working with EMS
working with ER gloves is obtrusive
working with family/friends
working with firefighters
working with homicidal patients
working with incarcerated patients
working with intoxicated patients
working with IT staff
working with lab tech
working with large patients
working with long paperwork
working with low SES population
working with medic
working with medicine machine
working with mental health evaluator
working with mentally altered patients
working with monitor
working with multiple patients
working with multiple tasks
working with non-english speaking patients
working with nurse practitioner
working with orthostatics
working with PA (physician's assistant)
working with pastor
working with patient visitors
working with patients of opposite gender
working with patients who hoard medicine
working with pediatric patients
working with pharmacist
working with phlebotomist
working with physical therapists
working with poison control
working with police
working with potentially contaminated patients
working with psych patients
working with radiology
working with respiratory therapist

working with rowdy patients
working with safety equipment
working with scanners
working with security
working with sexual harassment
working with shaking patients
working with sharp objects
working with similarly named patients
working with suicidal patients
working with the lab
working with touch screen
working with transporters
working with uncooperative patients
working with unescorted patients
working with unfamiliar problems
working with uninsured patients
working with unsatisfied patients
working with unstable patients
working with violent patients
working with wounded patients

B.5.2 Functional needs

accommodate patients
adapt resources appropriately
address patient needs
administer flu swab
admit patients
alert staff
allow patient decisions
answer phone calls
assign patients
calculate medicine amounts
change equipment
change equipment between patients
chart information digitally
chart information with admission orders
classify patients
clean bodily fluids
collect urine samples
communicate information
conduct communicable disease cultures
defibrillate patients
deliver babies
deliver labs
deliver oxygen
diagnose patients
discharge patients
distribute controlled drugs
do CPR
do medication reconciliations
do pelvic exam
document vital signs
double check calculations
double check staff
draw blood
educate patients
educate staff
eliminate double documentation
explain home care
find equipment
find staff
fire nurse
follow procedures
follow procedures correctly
give out cab ticket
hang patient blood
ID patients

insert foley
insert nasal gastric tube
interact with Medicaid
intervene crisis situation
label medications
label samples
lay out hospital
lift item
lock doors
look up dosages
manage foleys
medicate patient
monitor fetal heart rate
monitor lab work
monitor medications
monitor patient vitals
monitor patients
notify staff
obtain consent
order medicine
order medicines logically
order supplies
order x-rays
organize work
prepare patient
prepare patient room
prepare staff
present information
prevent missed steps
prevent patient theft
prioritize lab and lab results
protect patients
protect staff
provide home health
provide lab results
provide medical records
provide medical supplies
provide medication dosage
provide pet therapy
provide respiratory care
put in catheter
reassess triage patients
recycle equipment
reduce waste
request a court order
restrain patients

run CT scan
scan blood bags
scan medications
scan supplies
screen patients
seclude patients
secure supplies
sedate patients
send tests away to be read
start a saline lock
start EKGs
stitch up patient
stock medications
support nurses
take blood pressure
take body temperatures
train new nurse
transfer patient care
transport patients
treat burns
triage patients
troubleshoot computer system
uncuff prisoners
use accudose machine
use computer system
use CPOE
use EMAR scanning
use equipment
use internet
use Nighthawk
use paper charts
use pepper spray
use phone translator
use PICIS
use printer
use protocol
use pumps
use technology
wear gloves

B.5.3. Usability needs

accommodate patients of different acuity levels
accommodate patients of various ages
accommodate patients of various sizes
adapt resources appropriately
address patient needs
administer flu swab
admit patients
admit patients from holding area
admit patients quickly
admit patients through triage window
admit patients through triages readily
admit patients to beds
alert staff of errors through feedback
alert staff of patient movement
alert staff to mobilize
answer phone calls
arriving by ambulance
arriving by car
assign nurse of specific gender appropriately
assign patients in rooms close together
assign patients logically
assign patients to flex beds
assign staff efficiently
assign staff within physical proximity
attend to lab needs properly
hair huggers available
bedside toilets available
being new
being on call
blood bank computerized
blood labs available
bodily fluids exposed
chart information
chart information digitally
chart information digitally automatically
chart information on paper (non-digitally)
chart information quickly
chart information verbally
chart information with admission orders
chart information with medication error report
chart information with reported pain level
classify patients based on acuity
clean bodily fluids
close doors
communicate information (decision rationale) with staff

communicate information with accessible call system
communicate information with non-English speaking patient
communicate information with non-English speaking patient quickly
communicate information with the family
communicate information with the patient
communicate information with the patient after discharge
communicate order information between physicians and nurses
communicating poorly
computer system backed up
computer system functioning effectively
computer system working precautionarily
CT scanner outside of ER
deliver labs
deliver labs via vacuum tube
diagnose patients correctly
distinguish equipment easily
distribute controlled drugs
do task efficiently
document vital signs quickly
doorways open
double check staff
eliminate double documentation
equipment in trauma bay
ER areas separated
ER setup
find equipment
find equipment easily
find equipment quickly
find staff quickly
fire nurse
focus attention appropriately
follow procedures correctly
give ABG
give out cab ticket
gurneys low to the ground
ID patients from 2 identifiers
intervene crisis situation
keep equipment consistent throughout rooms
lab upstairs
label medications clearly
label samples clearly
lay out hospital appropriately
lift item easily
lock doors
management corrects patient behavior
medicate patient by matching patient to medications

medicate patient correctly
medicate patient quickly
medicate patient with IV
medicate patient with medicine distributing armband
medicate patient with mentally altered status
medicate patients while tracking unadministered medications
medicate patients with similar names
monitor fetal heart rate
monitor patient vitals from pulse ox
monitor patient vitals wirelessly
monitor patients
monitor patients in suicide specific room
monitor patients on tracking boards
monitor patients through larger windows
monitor patients vitals quickly
notify staff of new orders
nurse station centrally located
order medicine accurately
order medicine digitally
order medicine verbally
order medicine with override
order medicine with override emergently
order medicines logically
organize work appropriately
panic button available
patient bed available
patients in waiting room
patients mobile
patients nude
pharmacy upstairs
portable monitors available
prepare patient for surgery
prepare staff physically
prescriptions online
present information
present information in multiple places
prevent missed steps
prevent patient theft
prioritize lab and lab results
protect patients
protect patients from "cookie cutter" care
protect patients from escape
protect patients from injury
protect patients from medication order errors
protect patients from mixups
protect patients from physical attack

protect patients from privacy invasions
protect patients from self-injury
protect patients from sharps
protect patients from unequal treatment
protect patients from unnecessary delays
protect staff
protect staff from contamination
protect staff from injuries during patient shocks
protect staff from physical attack
protect staff from self-injury
protect staff from sexual harassment
protect staff from sharps
protect staff from wet floors
provide hair hugger quickly
provide equipment in each room
provide home health
provide lab results quickly
provide medical records easily
provide medical supplies
provide medical supplies adequately
provide medical supplies portably
provide medication dosage appropriately
provide medication dosage readily
provide pet therapy
provide resources adequately
reduce waste
restrain patients
room organized well
rooms have enough space
run CT scan
scan medications
scan medications sequentially
scan supplies
screen patients for diseases
screen patients for drugs
screen patients for weapons
screen patients quickly
seclusion rooms available
secure supplies
send tests away to be read
serenity room available
staff stressed
stock medications in correct area
support nurses with additional nursing staff
support nurses with assistants
support nurses with backup computers

support nurses with heart attack teams
support nurses with patient transporters
support nurses with scribes
support nurses with tablets
technology is outdated
train new nurse
transfer patient care
transfer patient care to other hospital
transport patients on gurneys
treat patients repeatedly
triage patients
troubleshoot computer system easily
uncuff prisoners
use accudose machine
use computer system easily
use EMAR scanning
use equipment comfortably
use equipment easily
use equipment multi-dimensionally
use equipment safely
use internet
use paper charts
use phone translator
use PICIS
use printer
use protocol effectively
use pumps
use pumps effectively
use technology effectively
use tube system
ventilation adequate
waiting for doctor to see patient
workers in front of ER
working alone
working at an inner city hospital
working in an ambulance
working in an emotionally open environment
working in an isolation room
working in front of ER at night
working in ideal conditions
working in large hospitals
working in small hospitals
working together
working with abused patients
working with allergic reactions
working with angry patients

working with armed patients
working with athsmatic patients
working with automated software
working with cell phones
working with common problems
working with computers during triage
working with consulting physicians
working with counselor
working with critical patients
working with dead patients
working with deaf patients
working with disrespectful patients
working with doctors
working with ED techs
working with elderly people
working with EMS
working with ER gloves is obtrusive
working with family/friends
working with firefighters
working with homicidal patients
working with incarcerated patients
working with intoxicated patients
working with IT staff
working with lab tech
working with large patients
working with long paperwork
working with low SES population
working with medic
working with medicine machine
working with mental health evaluator
working with mentally altered patients
working with monitor
working with multiple patients
working with multiple tasks
working with non-english speaking patients
working with nurse practitioner
working with orthostatics
working with PA (physician's assistant)
working with pastor
working with patient visitors
working with patients of opposite gender
working with patients who hoard medicine
working with pediatric patients
working with pharmacist
working with phlebotomist
working with physical therapists

working with poison control
working with police
working with potentially contaminated patients
working with psych patients
working with radiology
working with respiratory therapist
working with rowdy patients
working with safety equipment
working with scanners
working with security
working with sexual harassment
working with shaking patients
working with sharp objects
working with similarly named patients
working with suicidal patients
working with the lab
working with touch screen
working with transporters
working with uncooperative patients
working with unescorted patients
working with unfamiliar problems
working with uninsured patients
working with unsatisfied patients
working with unstable patients
working with violent patients
working with wounded patients

B.5.4 Effectiveness

accommodate patients of different acuity levels
accommodate patients of various ages
accommodate patients of various sizes
adapt resources appropriately
address patient needs
admit patients from holding area
admit patients quickly
admit patients to beds
alert staff of patient movement
alert staff to mobilize
arriving by car
assign nurse of specific gender appropriately
assign patients logically
assign patients to flex beds
assign staff efficiently
attend to lab needs properly
chart information digitally automatically
chart information quickly
chart information verbally
chart information with admission orders
chart information with medication error report
chart information with reported pain level
classify patients based on acuity
close doors
communicate information (decision rationale) with staff
communicate information with non-English speaking patient
communicate information with non-English speaking patient quickly
communicate information with the family
communicate information with the patient
communicate information with the patient after discharge
communicate order information between physicians and nurses
diagnose patients correctly
distinguish equipment easily
double check staff
find equipment easily
find equipment quickly
find staff quickly
focus attention appropriately
follow procedures correctly
give ABG
give out cab ticket
gurneys low to the ground
ID patients from 2 identifiers
label medications clearly
label samples clearly

lift item easily
management corrects patient behavior
medicate patient by matching patient to medications
medicate patient correctly
medicate patient with mentally altered status
medicate patients while tracking unadministered medications
medicate patients with similar names
monitor patient vitals from pulse ox
monitor patient vitals wirelessly
monitor patients
monitor patients on tracking boards
monitor patients vitals quickly
notify staff of new orders
order medicine accurately
order medicine with override
order medicine with override emergently
organize work appropriately
prepare patient for surgery
prepare staff physically
prevent missed steps
prevent patient theft
prioritize lab and lab results
protect patients from "cookie cutter" care
protect patients from escape
protect patients from injury
protect patients from medication order errors
protect patients from mixups
protect patients from physical attack
protect patients from privacy invasions
protect patients from self-injury
protect patients from sharps
protect patients from unnecessary delays
protect staff from contamination
protect staff from injuries during patient shocks
protect staff from physical attack
protect staff from self-injury
protect staff from sexual harassment
protect staff from sharps
protect staff from wet floors
provide bair hugger quickly
provide equipment in each room
provide home health
provide lab results quickly
provide medical records easily
provide medical supplies portably
provide medication dosage appropriately

provide medication dosage readily
provide resources adequately
scan medications sequentially
screen patients for drugs
screen patients for weapons
secure supplies
stock medications in correct area
support nurses with additional nursing staff
support nurses with assistants
support nurses with backup computers
support nurses with heart attack teams
support nurses with tablets
technology is outdated
treat patients repeatedly
triage patients
troubleshoot computer system easily
use equipment comfortably
use equipment easily
use equipment multi-dimensionally
use equipment safely
use protocol effectively
use pumps effectively
use technology effectively

B.5.5 Efficiency needs

admit patients quickly
admit patients through triages readily
alert staff of errors through feedback
alert staff to mobilize
assign staff efficiently
assign staff within physical proximity
attend to lab needs properly
chart information
chart information on paper (non-digitally)
chart information with admission orders
classify patients based on acuity
communicate information with non-English speaking patient quickly
distinguish equipment easily
document vital signs quickly
find equipment easily
find equipment quickly
find staff quickly
focus attention appropriately
keep equipment consistent throughout rooms
lay out hospital appropriately
medicate patient by matching patient to medications
medicate patient quickly
medicate patient with IV
medicate patient with medicine distributing armband
monitor patients vitals quickly
notify staff of new orders
order medicine digitally
order medicine with override
order medicine with override emergently
order medicines logically
patients in waiting room
prepare staff physically
present information in multiple places
prioritize lab and lab results
protect patients from unnecessary delays
provide home health
provide medical records easily
provide medical supplies adequately
provide medication dosage readily
provide resources adequately
reduce waste
scan medications sequentially
scan supplies
screen patients quickly
secure supplies

stock medications in correct area
support nurses with assistants
technology is outdated
troubleshoot computer system easily
use computer system easily
use equipment easily
use equipment multi-dimensionally
use protocol effectively

B.5.6 Satisfaction needs

admit patients quickly
admit patients to beds
alert staff of patient movement
assign patients to flex beds
assign staff efficiently
attend to lab needs properly
being new
bodily fluids exposed
communicate information (decision rationale) with staff
communicate information with non-English speaking patient
communicate information with non-English speaking patient quickly
do task efficiently
find equipment quickly
find staff quickly
fire nurse
intervene crisis situation
lift item easily
management corrects patient behavior
medicate patient correctly
medicate patient quickly
medicate patients while tracking unadministered medications
monitor patient vitals wirelessly
monitor patients
nurse station centrally located
order medicine accurately
order medicines logically
patient bed available
prepare staff physically
present information in multiple places
prevent patient theft
protect patients
protect patients from "cookie cutter" care
protect patients from medication order errors
protect patients from mixups
protect patients from privacy invasions
protect patients from unequal treatment
protect patients from unnecessary delays
protect staff
protect staff from contamination
protect staff from injuries during patient shocks
protect staff from self-injury
protect staff from sexual harassment
protect staff from sharps
provide bair hugger quickly
provide equipment in each room

provide lab results quickly
provide medical supplies
provide medical supplies adequately
provide medical supplies portably
provide medication dosage readily
provide pet therapy
room organized well
rooms have enough space
screen patients for weapons
seclusion rooms available
secure supplies
support nurses with additional nursing staff
support nurses with assistants
support nurses with backup computers
support nurses with scribes
support nurses with tablets
technology is outdated
troubleshoot computer system easily
use equipment safely
use protocol effectively
waiting for doctor to see patient
working alone
working in an emotionally open environment
working together
working with angry patients
working with armed patients
working with common problems
working with dead patients
working with disrespectful patients
working with ER gloves is obtrusive
working with family/friends
working with homicidal patients
working with incarcerated patients
working with intoxicated patients
working with large patients
working with long paperwork
working with low SES population
working with mentally altered patients
working with multiple patients
working with multiple tasks
working with potentially contaminated patients
working with psych patients
working with sexual harassment
working with uncooperative patients
working with uninsured patients
working with unsatisfied patients

working with unstable patients
working with wounded patients

B.5.7 Context-of-use needs

adapt resources appropriately
admit patients from holding area
admit patients through triage window
admit patients through triages readily
alert staff of errors through feedback
alert staff of patient movement
alert staff to mobilize
answer phone calls
arriving by ambulance
arriving by car
assign nurse of specific gender appropriately
assign patients in rooms close together
assign patients logically
assign patients to flex beds
assign staff efficiently
assign staff within physical proximity
attend to lab needs properly
bair huggers available
bedside toilets available
being new
being on call
blood bank computerized
blood labs available
bodily fluids exposed
chart information digitally
chart information digitally automatically
chart information with admission orders
clean bodily fluids
close doors
communicate information (decision rationale) with staff
communicate information with accessible call system
communicate information with non-English speaking patient
communicate information with non-English speaking patient quickly
communicating poorly
computer system backed up
computer system functioning effectively
computer system working precautionarily
conduct communicable disease cultures
CT scanner outside of ER
deliver labs
deliver labs via vacuum tube
distinguish equipment easily
distribute controlled drugs
do task efficiently
doorways open

eliminate double documentation
equipment in trauma bay
ER areas separated
ER setup
find equipment
find equipment easily
find equipment quickly
find staff quickly
fire nurse
focus attention appropriately
give ABG
gurneys low to the ground
intervene crisis situation
keep equipment consistent throughout rooms
lab upstairs
lay out hospital appropriately
lift item easily
lock doors
management corrects patient behavior
medicate patient correctly
medicate patient quickly
medicate patients while tracking unadministered medications
medicate patients with similar names
monitor fetal heart rate
monitor patient vitals from pulse ox
monitor patient vitals wirelessly
monitor patients
monitor patients in suicide specific room
monitor patients on tracking boards
monitor patients through larger windows
monitor patients vitals quickly
nurse station centrally located
order medicine accurately
order medicine digitally
order medicine verbally
order medicine with override emergently
order medicines logically
panic button available
patient bed available
patients in waiting room
patients mobile
patients nude
pharmacy upstairs
portable monitors available
prepare staff physically
prescriptions online

present information
present information in multiple places
prevent patient theft
protect patients
protect patients from "cookie cutter" care
protect patients from escape
protect patients from medication order errors
protect patients from mixups
protect patients from privacy invasions
protect patients from sharps
protect patients from unequal treatment
protect patients from unnecessary delays
protect staff
protect staff from contamination
protect staff from injuries during patient shocks
protect staff from self-injury
protect staff from sexual harassment
protect staff from sharps
protect staff from wet floors
provide hair hugger quickly
provide equipment in each room
provide home health
provide lab results quickly
provide medical records easily
provide medical supplies
provide medical supplies adequately
provide medical supplies portably
provide medication dosage readily
provide pet therapy
restrain patients
room organized well
rooms have enough space
run CT scan
scan medications
scan medications sequentially
scan supplies
screen patients for diseases
screen patients for weapons
screen patients quickly
seclusion rooms available
secure supplies
send tests away to be read
serenity room available
staff stressed
support nurses with additional nursing staff
support nurses with assistants

support nurses with backup computers
support nurses with patient transporters
support nurses with scribes
support nurses with tablets
technology is outdated
train new nurse
transfer patient care
transfer patient care to other hospital
transport patients on gurneys
troubleshoot computer system easily
uncuff prisoners
use accudose machine
use computer system easily
use EMAR scanning
use equipment comfortably
use equipment multi-dimensionally
use equipment safely
use internet
use paper charts
use phone translator
use PICIS
use printer
use protocol effectively
use pumps
use pumps effectively
use technology effectively
use tube system
ventilation adequate
waiting for doctor to see patient
workers in front of ER
working alone
working at an inner city hospital
working in an ambulance
working in an emotionally open environment
working in an isolation room
working in front of ER at night
working in ideal conditions
working in large hospitals
working in small hospitals
working together
working with abused patients
working with allergic reactions
working with angry patients
working with armed patients
working with asthmatic patients
working with automated software

working with cell phones
working with common problems
working with computers during triage
working with consulting physicians
working with counselor
working with critical patients
working with dead patients
working with deaf patients
working with disrespectful patients
working with doctors
working with ED techs
working with elderly people
working with EMS
working with ER gloves is obtrusive
working with family/friends
working with firefighters
working with homicidal patients
working with incarcerated patients
working with intoxicated patients
working with IT staff
working with lab tech
working with large patients
working with long paperwork
working with low SES population
working with medic
working with medicine machine
working with mental health evaluator
working with mentally altered patients
working with monitor
working with multiple patients
working with multiple tasks
working with non-english speaking patients
working with nurse practitioner
working with orthostatics
working with PA (physician's assistant)
working with pastor
working with patient visitors
working with patients of opposite gender
working with patients who hoard medicine
working with pediatric patients
working with pharmacist
working with phlebotomist
working with physical therapists
working with poison control
working with police
working with potentially contaminated patients

working with psych patients
working with radiology
working with respiratory therapist
working with rowdy patients
working with safety equipment
working with scanners
working with security
working with sexual harassment
working with shaking patients
working with sharp objects
working with similarly named patients
working with suicidal patients
working with the lab
working with touch screen
working with transporters
working with uncooperative patients
working with unescorted patients
working with unfamiliar problems
working with uninsured patients
working with unsatisfied patients
working with unstable patients
working with violent patients
working with wounded patients

B.5.8 Activity context needs

adapt resources appropriately
alert staff of patient movement
alert staff to mobilize
answer phone calls
arriving by car
assign nurse of specific gender appropriately
assign patients in rooms close together
assign staff within physical proximity
attend to lab needs properly
hair huggers available
being new
being on call
chart information digitally
chart information verbally
chart information with admission orders
communicate information (decision rationale) with staff
computer system backed up
computer system functioning effectively
deliver labs
deliver labs via vacuum tube
distinguish equipment easily
distribute controlled drugs
focus attention appropriately
intervene crisis situation
keep equipment consistent throughout rooms
label samples clearly
lift item easily
medicate patients while tracking unadministered medications
monitor fetal heart rate
monitor patient vitals from pulse ox
monitor patients through larger windows
order medicine verbally
order medicine with override emergently
panic button available
patient bed available
patients in waiting room
patients mobile
patients nude
portable monitors available
prepare staff physically
present information
prevent patient theft
protect patients from sharps
protect staff from injuries during patient shocks
protect staff from sexual harassment

protect staff from sharps
protect staff from wet floors
provide home health
provide medical records easily
provide medical supplies
provide medical supplies adequately
restrain patients
run CT scan
scan medications sequentially
scan supplies
screen patients for diseases
screen patients quickly
send tests away to be read
staff stressed
support nurses with assistants
support nurses with patient transporters
support nurses with scribes
technology is outdated
uncuff prisoners
use computer system easily
use equipment comfortably
use equipment multi-dimensionally
use paper charts
use PICIS
use printer
use pumps
use pumps effectively
working at an inner city hospital
working in an ambulance
working in an isolation room
working in front of ER at night
working in ideal conditions
working in large hospitals
working in small hospitals
working with abused patients
working with allergic reactions
working with angry patients
working with armed patients
working with asthmatic patients
working with common problems
working with consulting physicians
working with counselor
working with critical patients
working with dead patients
working with deaf patients
working with disrespectful patients

working with elderly people
working with ER gloves is obtrusive
working with family/friends
working with firefighters
working with incarcerated patients
working with intoxicated patients
working with IT staff
working with lab tech
working with large patients
working with long paperwork
working with low SES population
working with mentally altered patients
working with multiple patients
working with multiple tasks
working with non-english speaking patients
working with orthostatics
working with pastor
working with patient visitors
working with patients of opposite gender
working with patients who hoard medicine
working with physical therapists
working with poison control
working with potentially contaminated patients
working with radiology
working with sexual harassment
working with shaking patients
working with sharp objects
working with similarly named patients
working with touch screen
working with transporters
working with uncooperative patients
working with unfamiliar problems
working with uninsured patients
working with unsatisfied patients
working with unstable patients
working with violent patients
working with wounded patients

B.5.9 Hygienic needs

bedside toilets available

bodily fluids exposed

clean bodily fluids

protect patients from sharps

protect staff from contamination

protect staff from sharps

screen patients for diseases

working with potentially contaminated patients

B.5.10 Physical needs

assign patients in rooms close together
ventilation adequate

B.5.11 Social needs

arriving by ambulance
arriving by car
assign staff efficiently
blood labs available
communicating poorly
equipment in trauma bay
protect staff from sexual harassment
train new nurse
transfer patient care
transfer patient care to other hospital
waiting for doctor to see patient
working in an emotionally open environment
working together
working with abused patients
working with consulting physicians
working with counselor
working with doctors
working with ED techs
working with EMS
working with family/friends
working with firefighters
working with homicidal patients
working with incarcerated patients
working with IT staff
working with lab tech
working with medic
working with mental health evaluator
working with nurse practitioner
working with PA (physician's assistant)
working with pastor
working with patient visitors
working with patients of opposite gender
working with pediatric patients
working with pharmacist
working with phlebotomist
working with physical therapists
working with poison control
working with police
working with psych patients
working with radiology
working with respiratory therapist
working with rowdy patients
working with security
working with similarly named patients
working with suicidal patients

working with the lab
working with unescorted patients
working with unstable patients

B.5.12 Spatial needs

admit patients from holding area
admit patients through triage window
admit patients through triages readily
alert staff of patient movement
arriving by ambulance
arriving by car
assign patients in rooms close together
assign staff within physical proximity
bair huggers available
close doors
communicate information with accessible call system
CT scanner outside of ER
deliver labs
deliver labs via vacuum tube
doorways open
equipment in trauma bay
ER areas separated
ER setup
give ABG
gurneys low to the ground
lab upstairs
lay out hospital appropriately
lock doors
medicate patients with similar names
monitor patients in suicide specific room
monitor patients through larger windows
nurse station centrally located
panic button available
patient bed available
patients mobile
pharmacy upstairs
protect patients from escape
provide medical supplies portably
room organized well
rooms have enough space
seclusion rooms available
secure supplies
send tests away to be read
serenity room available
support nurses with patient transporters
transport patients on gurneys
use tube system
ventilation adequate
workers in front of ER
working alone

working in an ambulance
working in an isolation room

B.5.13 Technological needs

alert staff of errors through feedback
alert staff of patient movement
blood bank computerized
chart information digitally automatically
communicate information with accessible call system
computer system backed up
computer system functioning effectively
computer system working precautionarily
eliminate double documentation
find equipment
find equipment easily
find equipment quickly
keep equipment consistent throughout rooms
monitor patient vitals wirelessly
monitor patients on tracking boards
monitor patients vitals quickly
order medicine digitally
portable monitors available
prescriptions online
present information
run CT scan
scan medications
scan supplies
support nurses with tablets
technology is outdated
troubleshoot computer system easily
use accudose machine
use computer system easily
use EMAR scanning
use internet
use phone translator
use PICIS
use printer
use technology effectively
use tube system
working with automated software
working with cell phones
working with computers during triage
working with medicine machine
working with monitor
working with safety equipment
working with scanners
working with touch screen

B.6 Fit Statistics for Selection of Poisson distribution

| Dependent variable | Shapiro-Wilk Test for Normality (Pr < W) | Fit Statistics | | Selected Distribution |
|----------------------|--|--|--|-----------------------|
| | | AIC | | |
| | | Model w/ Normal Distribution | Model w/ Poisson Distribution Log Link | |
| User needs | p > .05 | 189.83 $\chi^2(10, n = 22) = 2208.50$ | 189.50 $\chi^2(10, n = 22) = 21.64$ | Poisson |
| Functional needs | p > .05 | 145.34 $\chi^2(10, n = 22) = 292.25$ | 152.70 $\chi^2(10, n = 22) = 9.19$ | Poisson |
| Usability needs | p = .03 | 182.68 $\chi^2(10, n = 22) = 1595.50$ | 181.80 $\chi^2(10, n = 22) = 18.79$ | Poisson |
| Effectiveness needs | p > .05 | 152.30 $\chi^2(10, n = 22) = 401.00$ | 154.70 $\chi^2(10, n = 22) = 12.89$ | Poisson |
| Efficiency needs | p > .05 | 124.89 $\chi^2(10, n = 22) = 111.75$ | 131.60 $\chi^2(10, n = 22) = 9.24$ | Poisson |
| Satisfaction needs | p > .05 | 146.40 $\chi^2(10, n = 22) = 306.75$ | 150.90 $\chi^2(10, n = 22) = 10.97$ | Poisson |
| Context-of-use needs | p = .01 | 171.15 $\chi^2(10, n = 22) = 944.50$ | 171.52 $\chi^2(10, n = 22) = 14.58$ | Poisson |

| | | | | |
|---------------------|------------|---|--|---------|
| Activity needs | p = .03 | 140.94 $\chi^2(10, n = 22) = 239.25$ | 143.88 $\chi^2(10, n = 22) = 6.98$ | Poisson |
| Hygienic needs | p = .03 | 88.93 $\chi^2(10, n = 22) = 22.50$ | 90.30 $\chi^2(10, n = 22) = 14.94$ | Poisson |
| Physical needs | p < 0.0001 | 38.16 $\chi^2(10, n = 22) = 4.0$ | 25.34 $\chi^2(10, n = 22) = 1.25$ | Poisson |
| Social needs | p > .05 | 135.72 $\chi^2(10, n = 22) = 188.75$ | 137.55 $\chi^2(10, n = 22) = 14.19$ | Poisson |
| Spatial needs | p > .05 | 117.97 $\chi^2(10, n = 22) = 84.25$ | 125.51 $\chi^2(10, n = 22) = 12.30$ | Poisson |
| Technological needs | p > .05 | 100.75 $\chi^2(10, n = 22) = 38.50$ | 119.71 $\chi^2(10, n = 22) = 4.10$ | Poisson |
| Breadth | p = .0006 | -57.02 $\chi^2(10, n = 22) = 0.03$ | 66.25 $\chi^2(10, n = 22) = 0.03$ | Poisson |

B.7 SAS code for RQ1a-1 (i.e., quantity)

B.7.1 Total needs

```
proc glimmix plots=all;
title "ANOVA TOTAL NEEDS";
class setting questions time;
model NEEDS= setting questions time setting*questions questions*time setting*time
setting*questions*time/ dist=poisson link=log;
lsmeans setting time setting*time / adjust=tukey;
run;
```

The GLIMMIX Procedure

Convergence criterion (ABSGCONV=0.00001) satisfied.

Fit Statistics

| | |
|--------------------------|--------|
| -2 Log Likelihood | 165.50 |
| AIC (smaller is better) | 189.50 |
| AICC (smaller is better) | 224.16 |
| BIC (smaller is better) | 202.59 |
| CAIC (smaller is better) | 214.59 |
| HQIC (smaller is better) | 192.58 |
| Pearson Chi-Square | 21.64 |
| Pearson Chi-Square / DF | 2.16 |

Type III Tests of Fixed Effects

| Effect | Num DF | Den DF | F Value | Pr > F |
|----------------------|-----------|-----------|---------|--------|
| SETTING | 1 | 10 | 42.93 | <.0001 |
| QUESTIONS | 1 | 10 | 0.61 | 0.4531 |
| TIME | 2 | 10 | 16.80 | 0.0006 |
| SETTING*QUESTIONS | 1 | 10 | 0.53 | 0.4814 |
| QUESTIONS*TIME | 2 | 10 | 0.47 | 0.6407 |
| SETTING*TIME | 2 | 10 | 6.78 | 0.0138 |
| SETTING*QUESTIO*TIME | 2 | 10 | 2.07 | 0.1772 |

```

proc glimmix plots=all;
title "NEEDS - ie CONTRASTS FOR SETTING*TIME";
class setting time;
model NEEDS= setting time setting*time / dist=poisson link=log;
lsmeans setting time setting*time / adjust=tukey;
run;

```

SETTING*TIME Least Squares Means

| SETTING | TIME | Estimate | Standard Error | DF | t Value | Pr > t |
|---------|------|----------|----------------|----|---------|---------|
| 0 | 1 | 4.8790 | 0.04360 | 16 | 111.90 | <.0001 |
| 0 | 2 | 4.5326 | 0.03666 | 16 | 123.63 | <.0001 |
| 0 | 3 | 4.4573 | 0.05384 | 16 | 82.79 | <.0001 |
| 1 | 1 | 4.9733 | 0.05882 | 16 | 84.55 | <.0001 |
| 1 | 2 | 4.9972 | 0.05812 | 16 | 85.98 | <.0001 |
| 1 | 3 | 4.7536 | 0.06565 | 16 | 72.40 | <.0001 |

Differences of SETTING*TIME Least Squares Means
Adjustment for Multiple Comparisons: Tukey-Kramer

| SETTING | TIME | _SETTING | _TIME | Estimate | Standard Error | DF | t Value | Pr > t | Adj P |
|---------|------|----------|-------|----------|----------------|----|---------|---------|--------|
| 0 | 1 | 0 | 2 | 0.3464 | 0.05697 | 16 | 6.08 | <.0001 | 0.0002 |
| 0 | 1 | 0 | 3 | 0.4218 | 0.06928 | 16 | 6.09 | <.0001 | 0.0002 |
| 0 | 1 | 1 | 1 | -0.09427 | 0.07322 | 16 | -1.29 | 0.2162 | 0.7874 |
| 0 | 1 | 1 | 2 | -0.1182 | 0.07266 | 16 | -1.63 | 0.1233 | 0.5940 |
| 0 | 1 | 1 | 3 | 0.1254 | 0.07881 | 16 | 1.59 | 0.1311 | 0.6151 |
| 0 | 2 | 0 | 3 | 0.07535 | 0.06514 | 16 | 1.16 | 0.2643 | 0.8503 |
| 0 | 2 | 1 | 1 | -0.4407 | 0.06931 | 16 | -6.36 | <.0001 | 0.0001 |
| 0 | 2 | 1 | 2 | -0.4646 | 0.06872 | 16 | -6.76 | <.0001 | <.0001 |
| 0 | 2 | 1 | 3 | -0.2210 | 0.07520 | 16 | -2.94 | 0.0096 | 0.0847 |
| 0 | 3 | 1 | 1 | -0.5160 | 0.07974 | 16 | -6.47 | <.0001 | <.0001 |
| 0 | 3 | 1 | 2 | -0.5400 | 0.07923 | 16 | -6.82 | <.0001 | <.0001 |
| 0 | 3 | 1 | 3 | -0.2963 | 0.08491 | 16 | -3.49 | 0.0030 | 0.0299 |

B.7.2 Functional needs

```
proc glimmix plots=all;
title "ANOVA FUNCTIONAL";
class setting questions time;
model FUNCTIONAL= setting questions time setting*questions questions*time setting*time
setting*questions*time/ dist=poisson link=log;
run;
```

The GLIMMIX Procedure

Convergence criterion (ABSGCONV=0.00001) satisfied.

Fit Statistics

| | |
|--------------------------|--------|
| -2 Log Likelihood | 128.70 |
| AIC (smaller is better) | 152.70 |
| AICC (smaller is better) | 187.36 |
| BIC (smaller is better) | 165.79 |
| CAIC (smaller is better) | 177.79 |
| HQIC (smaller is better) | 155.78 |
| Pearson Chi-Square | 9.19 |
| Pearson Chi-Square / DF | 0.92 |

Type III Tests of Fixed Effects

| Effect | Num DF | Den DF | F Value | Pr > F |
|----------------------|-----------|-----------|---------|--------|
| SETTING | 1 | 10 | 17.94 | 0.0017 |
| QUESTIONS | 1 | 10 | 0.47 | 0.5082 |
| TIME | 2 | 10 | 7.29 | 0.0111 |
| SETTING*QUESTIONS | 1 | 10 | 0.00 | 0.9627 |
| QUESTIONS*TIME | 2 | 10 | 0.38 | 0.6928 |
| SETTING*TIME | 2 | 10 | 2.36 | 0.1452 |
| SETTING*QUESTIO*TIME | 2 | 10 | 0.36 | 0.7070 |

```

proc glimmix plots=all;
title "Functional poisson - ie CONTRASTS 1";
class setting time;
model FUNCTIONAL= setting time / dist=poisson link=log;
lsmeans setting time / adjust=tukey;
run;

```

Type III Tests of Fixed Effects

| Effect | Num DF | Den DF | F Value | Pr > F |
|---------|--------|--------|---------|--------|
| SETTING | 1 | 18 | 18.57 | 0.0004 |
| TIME | 2 | 18 | 9.26 | 0.0017 |

SETTING Least Squares Means

| SETTING | Estimate | Standard Error | DF | t Value | Pr > t |
|---------|----------|----------------|----|---------|---------|
| 0 | 3.5039 | 0.04503 | 18 | 77.81 | <.0001 |
| 1 | 3.8265 | 0.06018 | 18 | 63.58 | <.0001 |

**Differences of SETTING Least Squares Means
Adjustment for Multiple Comparisons: Tukey-Kramer**

| SETTING | _SETTING | Estimate | Standard Error | DF | t Value | Pr > t | Adj P |
|---------|----------|----------|----------------|----|---------|---------|--------|
| 0 | 1 | -0.3226 | 0.07486 | 18 | -4.31 | 0.0004 | 0.0004 |

TIME Least Squares Means

| TIME | Estimate | Standard Error | DF | t Value | Pr > t |
|------|----------|----------------|----|---------|---------|
| 1 | 3.8777 | 0.06037 | 18 | 64.24 | <.0001 |
| 2 | 3.6260 | 0.05691 | 18 | 63.71 | <.0001 |
| 3 | 3.4918 | 0.07306 | 18 | 47.79 | <.0001 |

The GLIMMIX Procedure

**Differences of TIME Least Squares Means
Adjustment for Multiple Comparisons: Tukey-Kramer**

| TIME | _TIME | Estimate | Standard Error | DF | t Value | Pr > t | Adj P |
|------|-------|----------|----------------|----|---------|---------|--------|
| 1 | 2 | 0.2517 | 0.08144 | 18 | 3.09 | 0.0063 | 0.0165 |
| 1 | 3 | 0.3859 | 0.09428 | 18 | 4.09 | 0.0007 | 0.0019 |
| 2 | 3 | 0.1342 | 0.09125 | 18 | 1.47 | 0.1588 | 0.3281 |

B.7.3 Usability needs

```
proc glimmix plots=all;
title "ANOVA USABILITY";
class setting questions time;
model USABILITY= setting questions time setting*questions questions*time setting*time
setting*questions*time/ dist=poisson link=log;
run;
```

The GLIMMIX Procedure

Convergence criterion (ABSGCONV=0.00001) satisfied.

Fit Statistics

| | |
|--------------------------|--------|
| -2 Log Likelihood | 157.80 |
| AIC (smaller is better) | 181.80 |
| AICC (smaller is better) | 216.47 |
| BIC (smaller is better) | 194.89 |
| CAIC (smaller is better) | 206.89 |
| HQIC (smaller is better) | 184.88 |
| Pearson Chi-Square | 18.79 |
| Pearson Chi-Square / DF | 1.88 |

Type III Tests of Fixed Effects

| Effect | Num DF | Den DF | F Value | Pr > F |
|----------------------|-----------|-----------|---------|--------|
| SETTING | 1 | 10 | 30.62 | 0.0002 |
| QUESTIONS | 1 | 10 | 0.32 | 0.5826 |
| TIME | 2 | 10 | 16.09 | 0.0007 |
| SETTING*QUESTIONS | 1 | 10 | 0.33 | 0.5769 |
| QUESTIONS*TIME | 2 | 10 | 0.62 | 0.5568 |
| SETTING*TIME | 2 | 10 | 4.88 | 0.0331 |
| SETTING*QUESTIO*TIME | 2 | 10 | 1.61 | 0.2472 |

```

proc glimmix plots=all;
title "Usability poisson - ie CONTRASTS 1";
class setting time;
model usability= setting TIME setting*time / dist=poisson link=log;
lsmeans setting time setting*time / adjust=tukey;
run;

```

SETTING*TIME Least Squares Means

| SETTING | TIME | Estimate | Standard Error | DF | t Value | Pr > t |
|---------|------|----------|----------------|----|---------|---------|
| 0 | 1 | 4.6868 | 0.04800 | 16 | 97.64 | <.0001 |
| 0 | 2 | 4.3241 | 0.04069 | 16 | 106.27 | <.0001 |
| 0 | 3 | 4.2449 | 0.05987 | 16 | 70.90 | <.0001 |
| 1 | 1 | 4.7749 | 0.06496 | 16 | 73.51 | <.0001 |
| 1 | 2 | 4.7622 | 0.06537 | 16 | 72.85 | <.0001 |
| 1 | 3 | 4.5218 | 0.07372 | 16 | 61.34 | <.0001 |

Differences of SETTING*TIME Least Squares Means
Adjustment for Multiple Comparisons: Tukey-Kramer

| SETTING | TIME | _SETTING | _TIME | Estimate | Standard Error | DF | t Value | Pr > t | Adj P |
|---------|------|----------|-------|----------|----------------|----|---------|---------|--------|
| 0 | 1 | 0 | 2 | 0.3626 | 0.06293 | 16 | 5.76 | <.0001 | 0.0004 |
| 0 | 1 | 0 | 3 | 0.4418 | 0.07674 | 16 | 5.76 | <.0001 | 0.0004 |
| 0 | 1 | 1 | 1 | -0.08816 | 0.08077 | 16 | -1.09 | 0.2912 | 0.8777 |
| 0 | 1 | 1 | 2 | -0.07542 | 0.08110 | 16 | -0.93 | 0.3662 | 0.9328 |
| 0 | 1 | 1 | 3 | 0.1650 | 0.08797 | 16 | 1.88 | 0.0791 | 0.4502 |
| 0 | 2 | 0 | 3 | 0.07922 | 0.07239 | 16 | 1.09 | 0.2900 | 0.8766 |
| 0 | 2 | 1 | 1 | -0.4508 | 0.07665 | 16 | -5.88 | <.0001 | 0.0003 |
| 0 | 2 | 1 | 2 | -0.4380 | 0.07700 | 16 | -5.69 | <.0001 | 0.0004 |
| 0 | 2 | 1 | 3 | -0.1977 | 0.08420 | 16 | -2.35 | 0.0321 | 0.2320 |
| 0 | 3 | 1 | 1 | -0.5300 | 0.08834 | 16 | -6.00 | <.0001 | 0.0002 |
| 0 | 3 | 1 | 2 | -0.5173 | 0.08864 | 16 | -5.84 | <.0001 | 0.0003 |
| 0 | 3 | 1 | 3 | -0.2769 | 0.09497 | 16 | -2.92 | 0.0101 | 0.0884 |

B.7.4 Effectiveness needs

```
proc glimmix plots=all;
title "ANOVA EFFECTIVENESS";
class setting questions time;
model EFFECTIVENESS= setting questions time setting*questions questions*time setting*time
setting*questions*time/ dist=poisson link=log;
run;
```

The GLIMMIX Procedure

Convergence criterion (ABSGCONV=0.00001) satisfied.

Fit Statistics

| | |
|--------------------------|--------|
| -2 Log Likelihood | 130.70 |
| AIC (smaller is better) | 154.70 |
| AICC (smaller is better) | 189.37 |
| BIC (smaller is better) | 167.80 |
| CAIC (smaller is better) | 179.80 |
| HQIC (smaller is better) | 157.79 |
| Pearson Chi-Square | 12.89 |
| Pearson Chi-Square / DF | 1.29 |

Type III Tests of Fixed Effects

| Effect | Num DF | Den DF | F Value | Pr > F |
|----------------------|-----------|-----------|---------|--------|
| SETTING | 1 | 10 | 10.79 | 0.0082 |
| QUESTIONS | 1 | 10 | 0.84 | 0.3799 |
| TIME | 2 | 10 | 9.75 | 0.0045 |
| SETTING*QUESTIONS | 1 | 10 | 0.09 | 0.7694 |
| QUESTIONS*TIME | 2 | 10 | 0.37 | 0.6984 |
| SETTING*TIME | 2 | 10 | 1.97 | 0.1893 |
| SETTING*QUESTIO*TIME | 2 | 10 | 1.45 | 0.2798 |

```

proc glimmix plots=all;
title "EFFECTIVENESS poisson - ie CONTRASTS 1";
class setting time;
model EFFECTIVENESS= setting time / dist=poisson link=log;
lsmeans setting time / adjust=tukey;
run;

```

Type III Tests of Fixed Effects

| Effect | Num DF | Den DF | F Value | Pr > F |
|---------|--------|--------|---------|--------|
| SETTING | 1 | 18 | 12.15 | 0.0026 |
| TIME | 2 | 18 | 10.96 | 0.0008 |

SETTING Least Squares Means

| SETTING | Estimate | Standard Error | DF | t Value | Pr > t |
|---------|----------|----------------|----|---------|---------|
| 0 | 3.4344 | 0.04678 | 18 | 73.42 | <.0001 |
| 1 | 3.7079 | 0.06383 | 18 | 58.09 | <.0001 |

Differences of SETTING Least Squares Means
Adjustment for Multiple Comparisons: Tukey-Kramer

| SETTING | _SETTING | Estimate | Standard Error | DF | t Value | Pr > t | Adj P |
|---------|----------|----------|----------------|----|---------|---------|--------|
| 0 | 1 | -0.2736 | 0.07846 | 18 | -3.49 | 0.0026 | 0.0026 |

TIME Least Squares Means

| TIME | Estimate | Standard Error | DF | t Value | Pr > t |
|------|----------|----------------|----|---------|---------|
| 1 | 3.8021 | 0.06266 | 18 | 60.67 | <.0001 |
| 2 | 3.5723 | 0.05851 | 18 | 61.06 | <.0001 |
| 3 | 3.3390 | 0.07875 | 18 | 42.40 | <.0001 |

The GLIMMIX Procedure

Differences of TIME Least Squares Means
Adjustment for Multiple Comparisons: Tukey-Kramer

| TIME | _TIME | Estimate | Standard Error | DF | t Value | Pr > t | Adj P |
|------|-------|----------|----------------|----|---------|---------|--------|
| 1 | 2 | 0.2299 | 0.08384 | 18 | 2.74 | 0.0134 | 0.0341 |
| 1 | 3 | 0.4631 | 0.09998 | 18 | 4.63 | 0.0002 | 0.0006 |
| 2 | 3 | 0.2332 | 0.09645 | 18 | 2.42 | 0.0264 | 0.0650 |

B.7.5 Efficiency needs

```
proc glimmix plots=all;
title "ANOVA EFFICIENCY";
class setting questions time;
model EFFICIENCY= setting questions time setting*questions questions*time setting*time
setting*questions*time/ dist=poisson link=log;
run;
```

Convergence criterion (GCONV=1E-8) satisfied.

Fit Statistics

| | |
|--------------------------|--------|
| -2 Log Likelihood | 107.60 |
| AIC (smaller is better) | 131.60 |
| AICC (smaller is better) | 166.27 |
| BIC (smaller is better) | 144.70 |
| CAIC (smaller is better) | 156.70 |
| HQIC (smaller is better) | 134.69 |
| Pearson Chi-Square | 9.24 |
| Pearson Chi-Square / DF | 0.92 |

Type III Tests of Fixed Effects

| Effect | Num DF | Den DF | F Value | Pr > F |
|----------------------|-----------|-----------|---------|--------|
| SETTING | 1 | 10 | 5.14 | 0.0468 |
| QUESTIONS | 1 | 10 | 2.27 | 0.1630 |
| TIME | 2 | 10 | 6.02 | 0.0192 |
| SETTING*QUESTIONS | 1 | 10 | 0.32 | 0.5830 |
| QUESTIONS*TIME | 2 | 10 | 1.46 | 0.2778 |
| SETTING*TIME | 2 | 10 | 0.09 | 0.9129 |
| SETTING*QUESTIO*TIME | 2 | 10 | 0.12 | 0.8907 |

```

proc glimmix plots=all;
title "EFFICIENCY Model - poisson ie CONTRASTS";
class time;
model EFFICIENCY= time / dist=poisson link=log;
lsmeans time / adjust=tukey;
run;

```

Type III Tests of Fixed Effects

| Effect | Num DF | Den DF | F Value | Pr > F |
|--------|-----------|-----------|---------|--------|
| TIME | 2 | 19 | 6.32 | 0.0079 |

TIME Least Squares Means

| TIME | Estimate | Standard Error | DF | t Value | Pr > t |
|------|----------|-------------------|----|---------|---------|
| 1 | 2.9444 | 0.09366 | 19 | 31.44 | <.0001 |
| 2 | 2.6247 | 0.08513 | 19 | 30.83 | <.0001 |
| 3 | 2.4277 | 0.1213 | 19 | 20.02 | <.0001 |

Differences of TIME Least Squares Means
Adjustment for Multiple Comparisons: Tukey-Kramer

| TIME | _TIME | Estimate | Standard Error | DF | t Value | Pr > t | Adj P |
|------|-------|----------|-------------------|----|---------|---------|--------|
| 1 | 2 | 0.3198 | 0.1266 | 19 | 2.53 | 0.0206 | 0.0514 |
| 1 | 3 | 0.5167 | 0.1532 | 19 | 3.37 | 0.0032 | 0.0086 |
| 2 | 3 | 0.1969 | 0.1482 | 19 | 1.33 | 0.1996 | 0.3970 |

B.7.6 Satisfaction needs

```
proc glimmix plots=all;
title "ANOVA SATISFACTION";
class setting questions time;
model SATISFACTION= setting questions time setting*questions questions*time setting*time
setting*questions*time/ dist=poisson link=log;
run;
```

Convergence criterion (ABSGCONV=0.00001) satisfied.

Fit Statistics

| | |
|--------------------------|--------|
| -2 Log Likelihood | 126.90 |
| AIC (smaller is better) | 150.90 |
| AICC (smaller is better) | 185.56 |
| BIC (smaller is better) | 163.99 |
| CAIC (smaller is better) | 175.99 |
| HQIC (smaller is better) | 153.98 |
| Pearson Chi-Square | 10.97 |
| Pearson Chi-Square / DF | 1.10 |

Type III Tests of Fixed Effects

| Effect | Num DF | Den DF | F Value | Pr > F |
|----------------------|-----------|-----------|---------|--------|
| SETTING | 1 | 10 | 13.90 | 0.0039 |
| QUESTIONS | 1 | 10 | 0.05 | 0.8317 |
| TIME | 2 | 10 | 4.03 | 0.0519 |
| SETTING*QUESTIONS | 1 | 10 | 0.33 | 0.5790 |
| QUESTIONS*TIME | 2 | 10 | 0.25 | 0.7800 |
| SETTING*TIME | 2 | 10 | 1.81 | 0.2130 |
| SETTING*QUESTIO*TIME | 2 | 10 | 0.39 | 0.6901 |

```
proc glimmix plots=all;
title "SATISFACTION Model - poisson ie CONTRASTS";
class setting;
model SATISFACTION= setting / dist=poisson link=log;
lsmeans setting / adjust=tukey;
run;
```

SETTING Least Squares Means

| SETTING | Estimate | Standard Error | DF | t Value | Pr > t |
|---------|----------|-------------------|----|---------|---------|
| 0 | 3.3521 | 0.04678 | 20 | 71.66 | <.0001 |
| 1 | 3.6678 | 0.06523 | 20 | 56.23 | <.0001 |

Differences of SETTING Least Squares Means Adjustment for Multiple Comparisons: Tukey-Kramer

| SETTING | _SETTING | Estimate | Standard Error | DF | t Value | Pr > t | Adj P |
|---------|----------|----------|-------------------|----|---------|---------|--------|
| 0 | 1 | -0.3157 | 0.08027 | 20 | -3.93 | 0.0008 | 0.0008 |

B.7.7 Context-of-use needs

```
proc glimmix plots=all;
title "ANOVA CONTEXT";
class setting questions time;
model CONTEXT= setting questions time setting*questions questions*time setting*time
setting*questions*time/ dist=poisson link=log;
run;
```

Convergence criterion (ABSGCONV=0.00001) satisfied.

Fit Statistics

| | |
|--------------------------|--------|
| -2 Log Likelihood | 147.52 |
| AIC (smaller is better) | 171.52 |
| AICC (smaller is better) | 206.18 |
| BIC (smaller is better) | 184.61 |
| CAIC (smaller is better) | 196.61 |
| HQIC (smaller is better) | 174.60 |
| Pearson Chi-Square | 14.58 |
| Pearson Chi-Square / DF | 1.46 |

Type III Tests of Fixed Effects

| Effect | Num DF | Den DF | F Value | Pr > F |
|----------------------|-----------|-----------|---------|--------|
| SETTING | 1 | 10 | 27.87 | 0.0004 |
| QUESTIONS | 1 | 10 | 0.00 | 0.9578 |
| TIME | 2 | 10 | 12.84 | 0.0017 |
| SETTING*QUESTIONS | 1 | 10 | 0.39 | 0.5447 |
| QUESTIONS*TIME | 2 | 10 | 0.31 | 0.7410 |
| SETTING*TIME | 2 | 10 | 4.23 | 0.0466 |
| SETTING*QUESTIO*TIME | 2 | 10 | 1.28 | 0.3195 |

```

proc glimmix plots=all;
title "Context Model - poisson ie CONTRASTS";
class setting time;
model context= setting time / dist=poisson link=log;
lsmeans setting time / adjust=tukey;
run;

```

Type III Tests of Fixed Effects

| Effect | Num DF | Den DF | F Value | Pr > F |
|---------|--------|--------|---------|--------|
| SETTING | 1 | 18 | 28.59 | <.0001 |
| TIME | 2 | 18 | 16.76 | <.0001 |

SETTING Least Squares Means

| SETTING | Estimate | Standard Error | DF | t Value | Pr > t |
|---------|----------|----------------|----|---------|---------|
| 0 | 4.1377 | 0.03280 | 18 | 126.15 | <.0001 |
| 1 | 4.4321 | 0.04445 | 18 | 99.70 | <.0001 |

**Differences of SETTING Least Squares Means
Adjustment for Multiple Comparisons: Tukey-Kramer**

| SETTING | _SETTING | Estimate | Standard Error | DF | t Value | Pr > t | Adj P |
|---------|----------|----------|----------------|----|---------|---------|--------|
| 0 | 1 | -0.2944 | 0.05505 | 18 | -5.35 | <.0001 | <.0001 |

TIME Least Squares Means

| TIME | Estimate | Standard Error | DF | t Value | Pr > t |
|------|----------|----------------|----|---------|---------|
| 1 | 4.4954 | 0.04431 | 18 | 101.45 | <.0001 |
| 2 | 4.2399 | 0.04183 | 18 | 101.35 | <.0001 |
| 3 | 4.1195 | 0.05335 | 18 | 77.22 | <.0001 |

The GLIMMIX Procedure

**Differences of TIME Least Squares Means
Adjustment for Multiple Comparisons: Tukey-Kramer**

| TIME | _TIME | Estimate | Standard Error | DF | t Value | Pr > t | Adj P |
|------|-------|----------|----------------|----|---------|---------|--------|
| 1 | 2 | 0.2556 | 0.05971 | 18 | 4.28 | 0.0005 | 0.0012 |
| 1 | 3 | 0.3759 | 0.06893 | 18 | 5.45 | <.0001 | <.0001 |
| 2 | 3 | 0.1203 | 0.06669 | 18 | 1.80 | 0.0879 | 0.1964 |

B.7.8 Activity needs

```
proc glimmix plots=all;
title "ANOVA ACTIVITY";
class setting questions time;
model ACTIVITY= setting questions time setting*questions questions*time setting*time
setting*questions*time/ dist=poisson link=log;
run;
```

Convergence criterion (ABSGCONV=0.00001) satisfied.

Fit Statistics

| | |
|--------------------------|--------|
| -2 Log Likelihood | 119.88 |
| AIC (smaller is better) | 143.88 |
| AICC (smaller is better) | 178.54 |
| BIC (smaller is better) | 156.97 |
| CAIC (smaller is better) | 168.97 |
| HQIC (smaller is better) | 146.96 |
| Pearson Chi-Square | 6.98 |
| Pearson Chi-Square / DF | 0.70 |

Type III Tests of Fixed Effects

| Effect | Num DF | Den DF | F Value | Pr > F |
|----------------------|-----------|-----------|---------|--------|
| SETTING | 1 | 10 | 17.61 | 0.0018 |
| QUESTIONS | 1 | 10 | 7.21 | 0.0229 |
| TIME | 2 | 10 | 12.80 | 0.0017 |
| SETTING*QUESTIONS | 1 | 10 | 0.01 | 0.9182 |
| QUESTIONS*TIME | 2 | 10 | 1.41 | 0.2898 |
| SETTING*TIME | 2 | 10 | 2.32 | 0.1492 |
| SETTING*QUESTIO*TIME | 2 | 10 | 0.49 | 0.6286 |

```
proc glimmix plots=all;
title "Activity Model 1 - poisson ie CONTRASTS";
class setting questions time;
model ACTIVITY= setting questions time / dist=poisson link=log;
lsmeans setting questions time / adjust=tukey;
run;
```

Type III Tests of Fixed Effects

| Effect | Num DF | Den DF | F Value | Pr > F |
|-----------|--------|--------|---------|--------|
| SETTING | 1 | 17 | 18.40 | 0.0005 |
| QUESTIONS | 1 | 17 | 5.57 | 0.0305 |
| TIME | 2 | 17 | 15.21 | 0.0002 |

SETTING Least Squares Means

| SETTING | Estimate | Standard Error | DF | t Value | Pr > t |
|---------|----------|----------------|----|---------|---------|
| 0 | 3.2227 | 0.05178 | 17 | 62.23 | <.0001 |
| 1 | 3.5856 | 0.06773 | 17 | 52.94 | <.0001 |

Differences of SETTING Least Squares Means
Adjustment for Multiple Comparisons: Tukey-Kramer

| SETTING | _SETTING | Estimate | Standard Error | DF | t Value | Pr > t | Adj P |
|---------|----------|----------|----------------|----|---------|---------|--------|
| 0 | 1 | -0.3629 | 0.08462 | 17 | -4.29 | 0.0005 | 0.0005 |

The GLIMMIX Procedure

QUESTIONS Least Squares Means

| QUESTIONS | Estimate | Standard Error | DF | t Value | Pr > t |
|-----------|----------|----------------|----|---------|---------|
| 0 | 3.3092 | 0.06141 | 17 | 53.89 | <.0001 |
| 1 | 3.4991 | 0.05619 | 17 | 62.27 | <.0001 |

Differences of QUESTIONS Least Squares Means
Adjustment for Multiple Comparisons: Tukey-Kramer

| QUESTIONS | _QUESTIONS | Estimate | Standard Error | DF | t Value | Pr > t | Adj P |
|-----------|------------|----------|----------------|----|---------|---------|--------|
| 0 | 1 | -0.1900 | 0.08049 | 17 | -2.36 | 0.0305 | 0.0305 |

TIME Least Squares Means

| TIME | Estimate | Standard Error | DF | t Value | Pr > t |
|------|----------|----------------|----|---------|---------|
| 1 | 3.7129 | 0.06557 | 17 | 56.62 | <.0001 |
| 2 | 3.2877 | 0.06716 | 17 | 48.95 | <.0001 |
| 3 | 3.2119 | 0.08400 | 17 | 38.24 | <.0001 |

Differences of TIME Least Squares Means
Adjustment for Multiple Comparisons: Tukey-Kramer

| TIME | _TIME | Estimate | Standard Error | DF | t Value | Pr > t | Adj P |
|------|-------|----------|----------------|----|---------|---------|--------|
| 1 | 2 | 0.4252 | 0.09222 | 17 | 4.61 | 0.0002 | 0.0007 |
| 1 | 3 | 0.5010 | 0.1060 | 17 | 4.73 | 0.0002 | 0.0005 |
| 2 | 3 | 0.07575 | 0.1061 | 17 | 0.71 | 0.4850 | 0.7587 |

B.7.9 Hygienic needs

```
proc glimmix plots=all;
title "ANOVA HYGIENIC";
class setting questions time;
model HYGIENIC= setting questions time setting*questions questions*time setting*time
setting*questions*time/ dist=poisson link=log;
run;
```

Convergence criterion (ABSGCONV=0.00001) satisfied.

Fit Statistics

| | |
|--------------------------|--------|
| -2 Log Likelihood | 66.30 |
| AIC (smaller is better) | 90.30 |
| AICC (smaller is better) | 124.96 |
| BIC (smaller is better) | 103.39 |
| CAIC (smaller is better) | 115.39 |
| HQIC (smaller is better) | 93.38 |
| Pearson Chi-Square | 14.94 |
| Pearson Chi-Square / DF | 1.49 |

Type III Tests of Fixed Effects

| Effect | Num DF | Den DF | F Value | Pr > F |
|----------------------|-----------|-----------|---------|--------|
| SETTING | 1 | 10 | 0.00 | 0.9758 |
| QUESTIONS | 1 | 10 | 0.00 | 0.9746 |
| TIME | 2 | 10 | 0.08 | 0.9254 |
| SETTING*QUESTIONS | 1 | 10 | 0.00 | 0.9716 |
| QUESTIONS*TIME | 2 | 10 | 0.19 | 0.8284 |
| SETTING*TIME | 2 | 10 | 0.33 | 0.7252 |
| SETTING*QUESTIO*TIME | 2 | 10 | 0.02 | 0.9799 |

B.7.10 Physical needs

```
proc glimmix plots=all;
title "ANOVA PHYSICAL";
class setting questions time;
model PHYSICAL= setting questions time setting*questions questions*time setting*time
setting*questions*time/ dist=poisson link=log;
run;
```

Convergence criterion (ABSGCONV=0.00001) satisfied.

Fit Statistics

| | |
|--------------------------|-------|
| -2 Log Likelihood | 14.16 |
| AIC (smaller is better) | 38.16 |
| AICC (smaller is better) | 72.83 |
| BIC (smaller is better) | 51.25 |
| CAIC (smaller is better) | 63.25 |
| HQIC (smaller is better) | 41.24 |
| Pearson Chi-Square | 4.00 |
| Pearson Chi-Square / DF | 0.40 |

Type III Tests of Fixed Effects

| Effect | Num DF | Den DF | F Value | Pr > F |
|----------------------|-----------|-----------|---------|--------|
| SETTING | 1 | 10 | 0.00 | 0.9961 |
| QUESTIONS | 1 | 10 | 0.00 | 0.9968 |
| TIME | 2 | 10 | 0.00 | 1.0000 |
| SETTING*QUESTIONS | 1 | 10 | 0.00 | 0.9965 |
| QUESTIONS*TIME | 2 | 10 | 0.00 | 1.0000 |
| SETTING*TIME | 2 | 10 | 0.00 | 1.0000 |
| SETTING*QUESTIO*TIME | 2 | 10 | 0.00 | 0.9997 |

B.7.11 Social needs

```
proc glimmix plots=all;
title "ANOVA SOCIAL";
class setting questions time;
model SOCIAL= setting questions time setting*questions questions*time setting*time
setting*questions*time/ dist=poisson link=log;
run;
```

Convergence criterion (GCONV=1E-8) satisfied.

Fit Statistics

| | |
|--------------------------|--------|
| -2 Log Likelihood | 113.55 |
| AIC (smaller is better) | 137.55 |
| AICC (smaller is better) | 172.22 |
| BIC (smaller is better) | 150.64 |
| CAIC (smaller is better) | 162.64 |
| HQIC (smaller is better) | 140.63 |
| Pearson Chi-Square | 14.19 |
| Pearson Chi-Square / DF | 1.42 |

Type III Tests of Fixed Effects

| Effect | Num DF | Den DF | F Value | Pr > F |
|----------------------|-----------|-----------|---------|--------|
| SETTING | 1 | 10 | 4.72 | 0.0549 |
| QUESTIONS | 1 | 10 | 0.03 | 0.8635 |
| TIME | 2 | 10 | 1.64 | 0.2416 |
| SETTING*QUESTIONS | 1 | 10 | 0.04 | 0.8447 |
| QUESTIONS*TIME | 2 | 10 | 0.50 | 0.6222 |
| SETTING*TIME | 2 | 10 | 0.21 | 0.8116 |
| SETTING*QUESTIO*TIME | 2 | 10 | 0.13 | 0.8766 |

B.7.12 Spatial needs

```
proc glimmix plots=all;
title "ANOVA SPATIAL";
class setting questions time;
model SPATIAL= setting questions time setting*questions questions*time setting*time
setting*questions*time/ dist=poisson link=log;
run;
```

Convergence criterion (GCONV=1E-8) satisfied.

Fit Statistics

| | |
|--------------------------|--------|
| -2 Log Likelihood | 101.51 |
| AIC (smaller is better) | 125.51 |
| AICC (smaller is better) | 160.18 |
| BIC (smaller is better) | 138.60 |
| CAIC (smaller is better) | 150.60 |
| HQIC (smaller is better) | 128.59 |
| Pearson Chi-Square | 12.30 |
| Pearson Chi-Square / DF | 1.23 |

Type III Tests of Fixed Effects

| Effect | Num DF | Den DF | F Value | Pr > F |
|----------------------|-----------|-----------|---------|--------|
| SETTING | 1 | 10 | 2.59 | 0.1388 |
| QUESTIONS | 1 | 10 | 1.63 | 0.2310 |
| TIME | 2 | 10 | 2.13 | 0.1698 |
| SETTING*QUESTIONS | 1 | 10 | 0.00 | 0.9510 |
| QUESTIONS*TIME | 2 | 10 | 0.08 | 0.9207 |
| SETTING*TIME | 2 | 10 | 3.70 | 0.0626 |
| SETTING*QUESTIO*TIME | 2 | 10 | 0.29 | 0.7512 |

B.7.13 Technological needs

```
proc glimmix plots=all;
title "ANOVA TECHNOLOGICAL";
class setting questions time;
model TECHNOLOGICAL= setting questions time setting*questions questions*time
setting*time setting*questions*time/ dist=poisson link=log;
run;
Convergence criterion (GCONV=1E-8) satisfied.
```

Fit Statistics

| | |
|--------------------------|--------|
| -2 Log Likelihood | 95.71 |
| AIC (smaller is better) | 119.71 |
| AICC (smaller is better) | 154.37 |
| BIC (smaller is better) | 132.80 |
| CAIC (smaller is better) | 144.80 |
| HQIC (smaller is better) | 122.79 |
| Pearson Chi-Square | 4.10 |
| Pearson Chi-Square / DF | 0.41 |

Type III Tests of Fixed Effects

| Effect | Num DF | Den DF | F Value | Pr > F |
|----------------------|-----------|-----------|---------|--------|
| SETTING | 1 | 10 | 5.37 | 0.0430 |
| QUESTIONS | 1 | 10 | 0.00 | 0.9595 |
| TIME | 2 | 10 | 3.56 | 0.0679 |
| SETTING*QUESTIONS | 1 | 10 | 0.01 | 0.9273 |
| QUESTIONS*TIME | 2 | 10 | 0.47 | 0.6403 |
| SETTING*TIME | 2 | 10 | 0.92 | 0.4288 |
| SETTING*QUESTIO*TIME | 2 | 10 | 1.07 | 0.3778 |

```
proc glimmix plots=all;
title "TECHNOLOGICAL Model - poisson ie CONTRASTS";
class setting;
model TECHNOLOGICAL= setting / dist=poisson link=log;
lsmeans setting / adjust=tukey;
run;
```

Type III Tests of Fixed Effects

| Effect | Num DF | Den DF | F Value | Pr > F |
|---------|-----------|-----------|---------|--------|
| SETTING | 1 | 20 | 6.52 | 0.0189 |

SETTING Least Squares Means

| SETTING | Estimate | Standard Error | DF | t Value | Pr > t |
|---------|----------|-------------------|----|---------|---------|
| 0 | 2.2513 | 0.08111 | 20 | 27.76 | <.0001 |
| 1 | 2.6027 | 0.1111 | 20 | 23.42 | <.0001 |

Differences of SETTING Least Squares Means Adjustment for Multiple Comparisons: Tukey-Kramer

| SETTING | _SETTING | Estimate | Standard Error | DF | t Value | Pr > t | Adj P |
|---------|----------|----------|-------------------|----|---------|---------|--------|
| 0 | 1 | -0.3514 | 0.1376 | 20 | -2.55 | 0.0189 | 0.0189 |

B.8 SAS code and output for RQ1a-2

```
proc glimmix plots=all;
title "breadth - binomial";
class setting questions time;
model MENTIONED_CATEGORIES/TOTAL_CATEGORIES = setting questions time
setting*questions questions*time setting*time setting*questions*time / dist=binomial link=logit;
random RESIDUAL;
run;
```

Convergence criterion (ABSGCONV=0.00001) satisfied.

Fit Statistics

| | |
|--------------------------|--------|
| -2 Log Likelihood | 45.45 |
| AIC (smaller is better) | 69.45 |
| AICC (smaller is better) | 104.11 |
| BIC (smaller is better) | 82.54 |
| CAIC (smaller is better) | 94.54 |
| HQIC (smaller is better) | 72.53 |
| Pearson Chi-Square | 5.09 |
| Pearson Chi-Square / DF | 0.51 |

Type III Tests of Fixed Effects

| Effect | Num DF | Den DF | F Value | Pr > F |
|----------------------|-------------------|-------------------|----------------|------------------|
| SETTING | 1 | 10 | 0.00 | 0.9642 |
| QUESTIONS | 1 | 10 | 0.00 | 0.9994 |
| TIME | 2 | 10 | 0.00 | 0.9989 |
| SETTING*QUESTIONS | 1 | 10 | 0.00 | 0.9994 |
| QUESTIONS*TIME | 2 | 10 | 0.00 | 0.9991 |
| SETTING*TIME | 2 | 10 | 0.00 | 0.9993 |
| SETTING*QUESTIO*TIME | 2 | 10 | 0.00 | 0.9991 |

B.9 Exclusion rules for the creation of the baseline decision tree

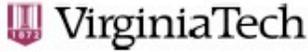
| Potential methods (inputs) | Node | Question | Decision | Exclusion rule | Potential methods (outputs) |
|--|----------------|----------------------------------|-----------------|---|--|
| G, I HH, H Mixed1, Mixed2 GHH, GH IHH, IH | 1.1 | Scheduling Issues? | No | None | G, I HH, H Mixed1, Mixed2 GHH, GH IHH, IH |
| G, I HH, H Mixed1, Mixed2 GHH, GH IHH, IH | <i>1.1.1</i> | <i>Session time constraints?</i> | <i>No</i> | <i>NONE</i> | <i>G, I HH, H Mixed1, Mixed2 GHH, GH IHH, IH</i> |
| G, I HH, H Mixed1, Mixed2 GHH, GH IHH, IH | <i>1.1.2</i> | <i>Session time constraints?</i> | <i>Yes</i> | <i>Exclude all group sessions since group sessions were significantly longer than individual sessions</i> | <i>I IHH IH</i> |
| G, I HH, H Mixed1, Mixed2 GHH, GH IHH, IH | <i>1.1.3</i> | <i>Session time constraints?</i> | <i>Maybe</i> | <i>Exclude combinations that solely use groups.</i> | <i>I HH, H Mixed1, Mixed2 IHH, IH</i> |
| G, I HH, H Mixed1, Mixed2 GHH, GH IHH, IH | 1.2 | Scheduling Issues? | Yes / Maybe | None | G, I HH, H Mixed1, Mixed2 GHH, GH IHH, IH |
| G, I HH, H Mixed1, Mixed2 GHH, GH IHH, IH | 1.2.1 | Groups together a problem? | No | None | G, I HH, H Mixed1, Mixed2 GHH, GH IHH, IH |
| G, I HH, H Mixed1, Mixed2 GHH, GH | <i>1.2.1.1</i> | <i>Session time constraints?</i> | <i>No</i> | <i>None</i> | <i>G, I HH, H Mixed1, Mixed2 GHH, GH</i> |

| | | | | | |
|---|-----------------------|---|---------------------|--|--|
| IHH, IH | | | | | <i>IHH, IH</i> |
| G, I HH, H Mixed1, Mixed2 GHH, GH IHH, IH | <i>1.2.1.2</i> | <i>Session time constraints?</i> | <i>Yes</i> | <i>Exclude all group sessions since group sessions were significantly longer than individual sessions</i> | <i>I IHH IH</i> |
| G, I HH, H Mixed1, Mixed2 GHH, GH IHH, IH | <i>1.2.1.3</i> | <i>Session time constraints?</i> | <i>Maybe</i> | <i>Exclude combinations that solely use groups.</i> | <i>I HH, H Mixed1, Mixed2 IHH, IH</i> |
| G, I HH, H Mixed1, Mixed2 GHH, GH IHH, IH | 1.2.2 | Groups together a problem? | Yes | Exclude all group sessions | I IHH IH |
| I IHH IH | <i>1.2.2.1</i> | <i>Session time constraints?</i> | <i>No</i> | <i>None</i> | <i>I IHH IH</i> |
| I IHH IH | <i>1.2.2.2</i> | <i>Session time constraints?</i> | <i>Yes</i> | <i>Exclude groups.</i> | <i>I IHH IH</i> |
| I IHH IH | <i>1.2.2.3</i> | <i>Session time constraints?</i> | <i>Maybe</i> | <i>Exclude sole use of groups</i> | <i>I IHH IH</i> |
| G, I HH, H Mixed1, Mixed2 GHH, GH IHH, IH | 1.2.3 | Groups together a problem? | Maybe | Exclude combinations that solely use groups. | I HH, H Mixed1, Mixed2 IHH, IH |
| I HH, H Mixed1, Mixed2 IHH, IH | <i>1.2.3.1</i> | <i>Session time constraints?</i> | <i>No</i> | <i>None</i> | <i>I HH, H Mixed1, Mixed2 IHH, IH</i> |
| I HH, H Mixed1, Mixed2 IHH, IH | <i>1.2.3.2</i> | <i>Session time constraints?</i> | <i>Yes</i> | <i>Exclude all group sessions since group sessions were significantly longer than individual sessions</i> | <i>I IHH IH</i> |
| <i>I</i> | <i>1.2.3.3</i> | <i>Session time</i> | <i>Maybe</i> | <i>Exclude combinations that solely use</i> | <i>I</i> |

| | | | | | |
|---|--|---------------------|--|----------------|---|
| <i>HH, H</i> <i>Mixed1, Mixed2</i> <i>IHH, IH</i> | | <i>constraints?</i> | | <i>groups.</i> | <i>HH, H</i> <i>Mixed1, Mixed2</i> <i>IHH, IH</i> |
|---|--|---------------------|--|----------------|---|

APPENDIX C: Phase 3 Documents

C.1 Virginia Tech IRB Approval



Office of Research Compliance
Institutional Review Board
2000 Kraft Drive, Suite 2000 (0497)
Blacksburg, Virginia 24060
540/231-4606 Fax 540/231-0959
e-mail irb@vt.edu
Website: www.irb.vt.edu

MEMORANDUM

DATE: September 13, 2011

TO: Woodrow Winchester, James D. Arthur, Brian M. Kleiner, Tonya L. Smith-Jackson, Kimberly Gausepohl

FROM: Virginia Tech Institutional Review Board (FWA00000572, expires May 31, 2014)

PROTOCOL TITLE: Design Opportunities within Emergency Rooms

IRB NUMBER: 11-696

Effective September 13, 2011, the Virginia Tech IRB Chair, Dr. David M. Moore, approved the new protocol for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report promptly to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at <http://www.irb.vt.edu/pages/responsibilities.htm> (please review before the commencement of your research).

PROTOCOL INFORMATION:

Approved as: Exempt, under 45 CFR 46.101(b) category(ies) 2, 4

Protocol Approval Date: 9/13/2011

Protocol Expiration Date: NA

Continuing Review Due Date*: NA

*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals / work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

Invent the Future

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
An equal opportunity, affirmative action institution

C.2 Study Announcement – Student Designers

Call for Participation in Virginia Tech Research Study Design Opportunities within Emergency Rooms

Who?:

Design students enrolled in either
ISE 3614 or IDS 2065

What?:

Give permission to have your submitted
lab assignments critiqued by an expert
in the medical and/or design field.
Note: critiques will occur outside the
Fall semester and will NOT influence any
assignment and/or course grades. The
course instructor will not know who is or
who is not participating.

How?:

Read & sign Informed Consent form and
complete demographic questionnaire
and give to Kim Gausepohl at start of
next class or during office hours

KIM'S OFFICE HOURS:

Whit 519C

TUES 09/20 & WED 09/21

9am-11am & 1pm-3pm



C.3 Informed Consent Form

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
Informed Consent for Participants
in Research Projects Involving Human Subjects

Title of Project: **Design Opportunities with Emergency Rooms**

Investigators: Kim Gausepohl, Dr. Woodrow Winchester, Dr. James D. Arthur, Dr. Tonya Smith-Jackson, Dr. Brian Kleiner

I. Purpose of this Research/Project

The National Institute for Occupational Safety and Health's (NIOSH) "Prevention through Design" initiative encourages the exploration of different methods to foster a collaborative dialogue between engineers and healthcare workers. The purpose of this study is to explore the impact of storytelling (i.e., narrative inquiry) during the conceptual design phase.

Approximately 180 students enrolled in Fall 2011 Virginia Tech design classes will participate in this phase of the project. Student participants will be adult design students who are **not** co-enrolled in the undergraduate research class ISE 4994 CRN 93873.

Approximately 6 stakeholder experts will critique students' submitted conceptual designs. Stakeholder experts will be either: product designers with at least 5 years of industry experience, emergency room nurses with at least 10 years of clinical experience, or hospital administrators with at least 10 years of clinical experience.

II. Procedures

Student Designers:

If participating as student designer you will complete the same lab assignments as all other students enrolled in the course. You will be asked to complete a demographic questionnaire, which will be used to assign your laboratory teammates. All other students will be assigned into laboratory teams randomly.

In-Class Lab #1: Functional Needs Identification

Following a 45-minute introduction to functional needs identification, you will analyze a series of Emergency Room (ER) nurses' stories to identify functional needs. You will download an electronic Word document containing the stories, instructions for your analysis, and a template for the assignment submission from the course Scholar site at <http://scholar.vt.edu>. You will work solely with students in your assigned design to complete the assignment, which will be due on the date designated in the course syllabus. You, or one of your teammates, will upload the completed submission to the VT Scholar course site following the instructions in the assignment details. This lab assignment is expected to take between 4-6 out-of-class hours to complete.

In-Class Lab #2: Usability Needs Identification

Following a 30-minute lecture on usability needs, you will analyze a series of ER stories to identify usability needs. You will use your Lab #1 assignment to complete this assignment. You

will download instructions for your analysis and a template for your assignment submission from the course Scholar site at <http://scholar.vt.edu> . You will work solely with students in your assigned design to complete the assignment, which will be due on the date designated in the course syllabus. You, or one of your teammates, will upload the completed submission to the VT Scholar course site following the instructions in the assignment details. This lab assignment is expected to take 2-4 out-of-class hours to complete.

In-Class Lab #3: Creating a Conceptual Design

Following a 30-minute lecture on conceptual design components (e.g., scenarios, storyboards, mockups), you will work with your design team to identify a design opportunity and form a design rationale based on the analysis you completed in Lab #1 and Lab #2. You will download assignment instructions and a template for your assignment submission from the course Scholar site at <http://scholar.vt.edu> . You will work solely with students in your assigned design to complete the assignment, which will be due on the date designated in the course syllabus. You, or one of your teammates, will upload the completed submission to the VT Scholar course site following the instructions in the assignment details. This lab assignment is expected to take 1-2 out-of-class hours to complete.

In-Class Lab #4: Conceptual Design

You will use the entire lab session to work with your assigned design team to create a conceptual design based on your previous lab work (i.e., Labs 1-3). You will download assignment instructions from the course Scholar site at <http://scholar.vt.edu> . You will work solely with students in your assigned design to complete the assignment, which will be due on the date designated in the course syllabus. You, or one of your teammates, will upload the completed submission to the VT Scholar course site following the instructions in the assignment details. This lab assignment is expected to take 3-6 out-of-class hours to complete.

Stakeholder Experts:

If participating as a stakeholder expert, you will critique 6 conceptual designs for products to be used in an emergency room environment. Virginia Tech student design teams created the conceptual designs as part of coursework within a human factors and/or design class. At a minimum, conceptual designs will consist of a storyboard, a design mock-up, and a listing of identified functional and usability user needs.

You will download PDF versions of each conceptual design from a Scholar project site at <http://scholar.vt.edu> . As a stakeholder expert you will critique the functionality and usability of each conceptual design following instructions provided available within the Scholar site. You will then use the online survey form designated within the instructions to submit your critiques. You will also rank the functionality and usability of each conceptual design in comparison to the other conceptual designs you critiqued using the online survey form.

Each critique is expected to take between 1-2 hours for a total estimated time commitment of 6-12 hours.

III. Risks

Student designers:

No more than minimal risk. You may feel uncomfortable having your lab assignments critiqued by stakeholder experts. To minimize this distress all expert critiques will occur outside of the

Fall 2011 semester so the critiques will not affect your course grade. Also, your name will be replaced with a random code (e.g., ID01) on all assignments critiqued by a stakeholder expert. No personally identifying information will be released to anyone outside of the research team.

Stakeholder experts:

No more than minimal risk. You may feel uncomfortable critiquing students' conceptual designs. To minimize this distress all student names will be replaced with a random code (e.g., ID01) on all conceptual design documents. In addition, critiques will occur outside of the Fall 2011 semester so the critiques will not affect students' grades. Also, your critique will not be shared with students.

IV. Benefits

An anticipated benefit are new and/or improved products that meet unmet ER nurses' needs. Please note that no promise or guarantee of benefits have been made to encourage you to participate.

V. Extent of Anonymity and Confidentiality

All information gathered from you is confidential. Information gathered from you will be coded to remove information that directly identifies you. You will be assigned a participant number, such as ID01, which will be used as identifiers in lieu of names. Information that associates you with your assigned number will be stored in a locked drawer in a Virginia Tech campus office.

It is possible that the Institutional Review Board (IRB) may view this study's collected data for auditing purposes. The IRB is responsible for the oversight of the protection of human subjects involved in research.

In some situations, it may be necessary for an investigator to break confidentiality. If a subject is believed to be a threat to herself/himself or others, the investigator will notify the appropriate authorities.

VI. Compensation

You will not be compensated for participation in this study.

VII. Freedom to Withdraw

You are free to withdraw from this study at any time without penalty. You are free not to answer any questions or respond to experimental situations that you choose without penalty.

VIII. Subject's Responsibilities

Student Designers:

I voluntarily agree to participate in this study. I have the following responsibilities:

- Complete lab assignments using the provided templates and designate a group member (which may be myself) to upload completed assignments to the Scholar course site at <http://scholar.vt.edu>

Stakeholder Experts:

I voluntarily agree to participate in this study. I have the following responsibilities:

- Download PDF copies of conceptual designs from the project site at <http://scholar.vt.edu>
- Critique each conceptual design following the provided instructions and online survey form
- Rank each conceptual design with the others I critiqued following the provided instructions and online survey form

IX. Subject's Permission

I have read the Consent Form and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent:

_____ Date _____
 Subject signature

Should I have any pertinent questions about this research or its conduct, and research subjects' rights, and whom to contact in the event of a research-related injury to the subject, I may contact:

Kim Gausepohl
 Investigator

540-449-4769, kgausepo@vt.edu
 Telephone/email

Dr. Woodrow W. Winchester III
 Faculty Advisor

540-231-5936, wwwinche@vt.edu
 Telephone/e-mail

Dr. Don Taylor
 ISE Dept Head

540-231-4771, don.taylor@vt.edu
 Telephone/e-mail

David M. Moore
 Chair, Virginia Tech Institutional Review
 Board for Human Subjects
 Office of Research Compliance
 2000 Kraft Drive, Suite 2000 (0497)
 Blacksburg, VA 24060

540-231-4991, moored@vt.edu
 Telephone/email

[NOTE: Subjects must be given a complete copy (or duplicate original) of the Signed Informed Consent.]

C.4 Demographic Questionnaire – Student Designers

Student Designer Demographic Questionnaire

Name: _____

Age (years): _____

Gender (circle one):

Female Male

VT Academic Level (circle one):

Freshman Sophomore Junior Senior

I am currently taking (circle all that apply):

IDS 2065 ISE 3614 8am ISE 3614 930am ISE 4994 w/ Dr. Winchester

Do you have previous USABILITY experience, such as taking a class or working on a project where USABILITY was a focus? (circle one)

No Yes

Do you have previous DESIGN experience, such as taking a class or working on a project where DESIGN was a focus? (circle one)

No Yes

Do you have previous REQUIREMENTS ENGINEERING experience, such as taking a class or working on a project where REQUIREMENTS ENGINEERING was a focus? (circle one)

No Yes

Have you ever created a conceptual design before? (circle one)

No Yes

Do you have any previous experience in healthcare, such as working in a healthcare setting or working on a healthcare related topic? (circle one)

No Yes

C.5 Course Documents

C.5.1 Lab 1 Assignment – Section A

LAB #1: INTRODUCTION TO USER NEEDS ANALYSIS

OVERVIEW OF COURSE LABS

The overall goal of the 4 course labs is to create a conceptual design for a product that meets Emergency Room (ER) nurses' needs.

You will analyze ER nurses' stories to:

- Identify functional needs (Lab #1)
- Identify usability needs (Lab #2)
- Identify a design opportunity & provide a rationale (Lab #3)
- Create a conceptual design (Lab #4)

INSTRUCTIONS FOR LAB #1

Step #1:

Download the transcript of nurses' stories from VT Scholar at <http://scholar.vt.edu>

Step #2

Identify functional needs following instructions on **Page 2** of this document. List all functional needs on the ***Functional Needs Template*** & upload into VT Scholar by the due date designated in the syllabus.

STEP 3 INSTRUCTIONS: IDENTIFY FUNCTIONAL NEEDS

1. Read each individual story
2. Go line by line & identify statements that support a functional need (i.e., WHAT the system or the worker needs to do)
3. List all functional needs following the format below (i.e., “active verb + object) into the Functional Needs Template
4. Upload completed functional needs list to the VT Scholar course site at <http://scholar.vt.edu>

DEFINITION: Functional

| | |
|------------|--|
| | States the functional need – “the WHAT” |
| functional | <i>What</i> the worker or current/needed system needs to do The worker will _____ The system will _____ |

FORMAT for Functional Needs:

| | |
|----------------------|--|
| active verb + object | e.g., deliver blood e.g., protect staff e.g., protect patients e.g., seclude patients e.g., prevent missed steps |
|----------------------|--|

C.5.2 Lab 1 Assignment – Section B

LAB #1: INTRODUCTION TO USER NEEDS ANALYSIS

OVERVIEW OF COURSE LABS

The overall goal of the 4 course labs is to create a conceptual design for a product that meets Emergency Room (ER) nurses' needs.

You will analyze ER nurses' stories to:

- Identify functional needs (Lab #1)
- Identify usability needs (Lab #2)
- Identify a design opportunity & provide a rationale (Lab #3)
- Create a conceptual design (Lab #4)

INSTRUCTIONS FOR LAB #1

Step #1:

Download the transcript of nurses' stories from VT Scholar at <http://scholar.vt.edu>

Step #2:

Form participant stories into concise narratives following instructions on **Page 2** of this document. Use the *Narrative Analysis Template* & upload into VT Scholar by the due date designated in the syllabus.

Step #3

Identify functional needs following instructions on **Page 7** of this document. List all functional needs on the *Functional Needs Template* & upload into VT Scholar by the due date designated in the syllabus.

STEP 2 INSTRUCTIONS: FORM STORIES INTO NARRATIVES

The purpose of this analysis step is to form all nurses' stories into a consistent format. Narrative analysis helps to *organize & reduce* the user data collected.

Narratives are structured by the following narrative components:

ABSTRACT (*optional*)

ORIENTATION (*optional*)

COMPLICATING ACTION (*required*)

RESOLUTION (*optional*)

EVALUATION (*optional*)

NOTE: All narratives MUST contain a complicating action. All other components are optional.

An example narrative is provided on **Page 3** of this document. Definitions of each narrative component are provided on **Page 4** of this document.

NARRATIVE COMPONENT DEFINITIONS & EXAMPLES

| Category | Required | Definition(s) | Example(s) |
|-------------|----------|------------------------------|--|
| Abstract | No | -summary | <ul style="list-style-type: none"> • And it's like they're all sick and backed up and stuff so I felt very unsafe because I felt like I needed to be in all 3 rooms at once. |
| Orientation | No | Contextual information | |
| | | Setting description | <ul style="list-style-type: none"> • We have a section of 4 patients usually • it's hard because we don't have sitters down here like somebody would sit with them like they might in the in-patient floors |
| | | Character description | <ul style="list-style-type: none"> • I had just gotten off of orientation and I was still brand new. • And they all ended up being ICU patients • I had a patient come in who was intoxicated • [The patient] had a foley in |
| | | Event background description | <ul style="list-style-type: none"> • I got 3 critical patients at once because you can't really tell the EMSes not to come in. • and it was the same situation where we didn't have enough nurses so I wasn't getting a lot of help, and so being a brand new nurse with that. • But you can't really restrain someone like that either because you're irritated that they just don't understand WHY they can't get up, WHY they are being restrained so it's making them more agitated and in the long run that can mess |

| | | | |
|----------------------------|------------|---|--|
| | | | <p>up.</p> <ul style="list-style-type: none"> • which is a tube that goes into the bladder and so to keep the foleys in you have to blow up a little balloon that is inside the bladder with 10ccs • ...you can use like chemical restraints or physical restraints – we couldn't chemically restrain [the patient] using sedative medication because of [the] levels [and organ function] |
| Complicating Action | YES | The "Plot" | |
| | | Temporal sequence of event(s) | <ul style="list-style-type: none"> • I saw [the patient] try to get up and walk and [the patient] was hooked to an IV and to the bag behind and you can't – that bag wasn't coming with [the patient]. |
| | | "Cause" in a "cause/effect" relationship | <ul style="list-style-type: none"> • So the EMSes come in • so [the patient] would try to get up |
| | | Conflict | <ul style="list-style-type: none"> • and [the patient] was ripping everything off and we needed [the patient] to be on the monitor, we needed [the patient] to keep [their] IV in. |
| Resolution | No | Result | |
| | | of temporal sequence of event(s) | |
| | | of conflict | <ul style="list-style-type: none"> • and I was worried that [the patient] was going to pull that out, pull out [the] IV... • and then I was worried because [the patient] was so big that the physical restraints would – |
| | | "Effect" in a "cause/effect" relationship | <ul style="list-style-type: none"> • so I felt like I was running my own little ICU in the back • and [the patient] kept almost plopping out of bed and falling so the charge nurse was like, "Sit down! Sit down!" and kind of reminding [the |

| | | | |
|------------|----|--|---|
| | | | patient] because [the patient] just wasn't getting it. |
| | | | |
| Evaluation | No | Why story told (i.e., indication of the "morale" of the story. | |
| | | Opinion of the events | <ul style="list-style-type: none"> • So you have to do a lot of things at once and if you get 3 in a row, back to back, it's really hard. |
| | | Reflection on the events | <ul style="list-style-type: none"> • I guess it was hard because the charge nurse at the time didn't know that all of my patients were that sick and those were the only beds that were open. • So that is something with patient safety that I felt that I was lacking and being a nurse I couldn't be their advocate because I couldn't be there for each of them • [This story] doesn't have much to do with equipment, just with the patient load. I guess it can kind of go with patient load like Participant_3 was talking about. |

STEP 3 INSTRUCTIONS: IDENTIFY FUNCTIONAL NEEDS

5. Read each individual narrative
6. Go line by line & identify statements that support a functional need (i.e., WHAT the system or the worker needs to do)
7. List all functional needs following the format below (i.e., “active verb + object) into the Functional Needs Template
8. Upload completed functional needs list to the VT Scholar course site at <http://scholar.vt.edu>

DEFINITION: Functional

| | |
|------------|--|
| | States the functional need – “the WHAT” |
| functional | <i>What</i> the worker or current/needed system needs to do The worker will _____ The system will _____ |

FORMAT for Functional Needs:

| | |
|----------------------|--|
| active verb + object | e.g., deliver blood e.g., protect staff e.g., protect patients e.g., seclude patients e.g., prevent missed steps |
|----------------------|--|

C.5.3 Lab 1 Functional Needs Template – Both Sections

Functional Needs Template:

DEFINITION: Functional

| | |
|------------|--|
| | States the functional need – “the WHAT” |
| functional | <i>What</i> the worker or current/needed system needs to do The worker will _____ The system will _____ |

FORMAT for Functional Needs:

| | |
|----------------------|--|
| active verb + object | e.g., deliver blood e.g., protect staff e.g., protect patients e.g., seclude patients e.g., prevent missed steps |
|----------------------|--|

The system and/or worker will:

[enter bulleted list of functional needs here]

C.5.4 Lab 2 Assignment – Section A

LAB #2: USABILITY NEEDS

OVERVIEW OF COURSE LABS

The overall goal of the 4 course labs is to create a conceptual design for a product that meets Emergency Room (ER) nurses' needs. You will analyze ER nurses' stories to:

- Identify functional needs (Lab #1)
- **Identify usability needs (Lab #2)**
- Identify a design opportunity & provide a rationale (Lab #3)
- Create a conceptual design (Lab #4)

INSTRUCTIONS FOR LAB #2

Step #1:

Open your Lab #1 documents (i.e., participant transcripts & functional needs list)

Step #2:

Identify usability needs following instructions on **Page 2** of this document. List all identified usability needs on the *Usability Needs Template* & upload into VT Scholar by the due date designated in the syllabus.

STEP 2 INSTRUCTIONS: IDENTIFY USABILITY NEEDS

1. Read each story within the participant transcripts
2. **Identify Usability Needs as defined below using *Usability Needs Template***
NOTE: an identified need may be categorized into 1 or more categories (e.g., effectiveness & efficiency)

| Usability Need | Definition | Example |
|-----------------------|--|--|
| effectiveness | Level of <u>accuracy & completeness</u> in which a user is able to satisfy the goals | protect nurses <i>from physical attack</i> |
| efficiency | Amount of <u>resources</u> used to achieve goals | deliver blood <i>quickly</i> |
| satisfaction | Perceived <u>comfort level and acceptability</u> while working towards goals | protect nurses <i>from physical attack</i> deliver blood <i>quickly</i> |
| activity context | -distractions -other tasks that may interfere -surprise/startle effect -strain & stress -influence on the working environment (e.g., not able to hear patient over noise) -workload & fatigue | working with critical patients working without breaks |
| hygienic context | -cleanliness/ sterile conditions required -cleaning -waste disposal | disposing hazardous waste |
| physical context | -climate conditions -light level -noise level | working with screaming patient |
| social context | -organization -transition of care -who is around (e.g., children, family, etc...) -responsibility (e.g., shared vs. alone) | working alone |
| spatial context | -architecture -location: -outdoors -patient transport (e.g., airplane, ambulance, car) | working in ambulance |
| technological context | -other technologies / devices involved | using blood pressure cuff |

3. Upload completed usability needs list to the VT Scholar course site at <http://scholar.vt.edu>

C.5.5 Lab 2 Assignment – Section B

LAB #2: USABILITY NEEDS

OVERVIEW OF COURSE LABS

The overall goal of the 4 course labs is to create a conceptual design for a product that meets Emergency Room (ER) nurses' needs. You will analyze ER nurses' stories to:

- Identify functional needs (Lab #1)
- **Identify usability needs (Lab #2)**
- Identify a design opportunity & provide a rationale (Lab #3)
- Create a conceptual design (Lab #4)

INSTRUCTIONS FOR LAB #2

Step #1:

Open your Lab #1 deliverables (i.e., narratives & functional needs list)

Step #2:

Identify usability needs following instructions on **Page 2** of this document. Refer to the ontology of user needs (Figure 1) as needed during your analysis. List all identified usability needs on the *Usability Needs Template* & upload into VT Scholar by the due date designated in the syllabus.

STEP 2 INSTRUCTIONS: IDENTIFY USABILITY NEEDS

1. Read each individual narrative that you created in Lab #1
2. **Read narrative line by line & Identify Effectiveness & Efficiency needs**

DEF: Effectiveness & Efficiency

| | Describes the functional need – “the HOW” |
|---------------|---|
| effectiveness | Level of <u>accuracy</u> & <u>completeness</u> in which a user is able to satisfy the goals |
| efficiency | Amount of <u>resources</u> used to achieve goals |

FORMAT

| | |
|---|---|
| active verb + object + prepositional phrase | e.g., protect nurses <i>from physical attack</i> e.g. protect patients <i>from self-injury</i> |
| active verb + object + adverb | e.g., deliver blood <i>quickly</i> |

a. Categorize identified user need(s) as effectiveness and/or efficiency using *Usability Needs Template*.

3. Read narrative line by line & Identify Context-of-Use Needs

DEF: activity, hygienic, physical, social, spatial, physical, technological context

| | |
|---------------|---|
| Activity | -distractions -other tasks that may interfere -surprise/startle effect -strain & stress -influence on the working environment (e.g., not able to hear patient over noise -workload & fatigue |
| Hygienic | -cleanliness/ sterile conditions required -cleaning -waste disposal |
| Physical | -climate conditions -light level -noise level |
| Social | -organization -transition of care -who is around (e.g., children, family, etc....) -responsibility (e.g., shared vs. alone) |
| Spatial | -architecture -location: -outdoors -patient transport (e.g., airplane, ambulance, car) |
| Technological | -other technologies / devices involved |

FORMAT context

| | |
|-------------------------------|---|
| object + adjective | e.g., seclusion room unavailable |
| gerund + prepositional phrase | e.g., working with psych patients e.g., working with mental health evaluator e.g., working with EMS |
| gerund + adjective | e.g., working alone |

- a. Categorize previously identified user needs (i.e., effectiveness & efficiency needs) in context-of-use category(s), as appropriate, using *Usability Needs Template*.
- b. Categorize newly identified user needs in appropriate context-of-use category(s) using *Usability Needs Template*

4. Identify Satisfaction Needs

- a. Categorize previously identified user needs (i.e., effectiveness, efficiency, context-of-use) in Satisfaction, as appropriate, using *Usability Needs Template*

DEF: satisfaction

| | |
|--------------|---|
| satisfaction | Perceived <u>comfort level</u> and <u>acceptability</u> while working towards goals |
|--------------|---|

FORMAT: any of the above formats

- 5. Upload completed usability needs list to the VT Scholar course site at <http://scholar.vt.edu>

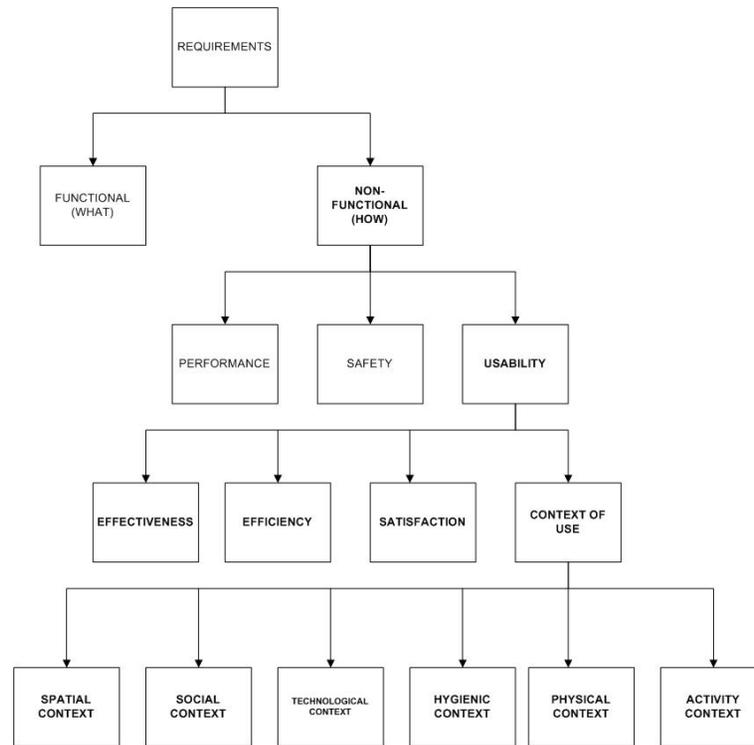


Figure 101. Ontology for user needs. Note you are only identifying functional & usability needs.

C.5.6 Lab 2 Usability Needs Template – Both Sections

Usability Needs Template:

Effectiveness:

[enter bulleted list of *effectiveness* needs here]

Efficiency:

[enter bulleted list of *efficiency* needs here]

Activity Context:

[enter bulleted list of *activity* context needs here]

Hygienic Context:

[enter bulleted list of *hygienic* context needs here]

Physical Context:

[enter bulleted list of *physical* context needs here]

Social Context:

[enter bulleted list of *social* context needs here]

Spatial Context:

[enter bulleted list of *spatial* context needs here]

Technological Context:

[enter bulleted list of *technological* context needs here]

Satisfaction:

[enter bulleted list of *satisfaction* needs here]

C.5.7 Lab 3 Assignment – Both Sections

LAB #3: IDENTIFY A DESIGN OPPORTUNITY

OVERVIEW OF COURSE LABS

The overall goal of the 4 course labs is to create a conceptual design for a product that meets Emergency Room (ER) nurses' needs. You will analyze ER nurses' stories to:

- Identify functional needs (Lab #1)
- Identify usability needs (Lab #2)
- **Identify a design opportunity & provide a rationale (Lab #3)**
- Create a conceptual design (Lab #4)

INSTRUCTIONS FOR LAB #3

Step #1:

Open your Lab #1 & Lab #2 documents (i.e., participant transcripts, functional needs list, & usability needs list)

Step #2:

After reviewing your Lab #1 & Lab #2 documents, identify a design opportunity (i.e., what problem your group's design intends to solve) & provide a rationale for why your group chose this design opportunity. Use the *Design Rationale Template* & upload into VT Scholar by the due date designated in the syllabus.

C.5.8 Lab 3 Design Rationale Template – Both Sections

Design Rationale Template

Identified Design Opportunity:

[paragraph description of the design opportunity here. What problem do you intend to address with your project?]

Rationale:

[paragraph description of your rationale here. Why is this design opportunity important? Why did you select this opportunity over other possible design opportunities?]

C.5.9 Lab 4 Assignment – Both Sections

LAB #4: CREATE A CONCEPTUAL DESIGN

OVERVIEW OF COURSE LABS

The overall goal of the 4 course labs is to create a conceptual design for a product that meets Emergency Room (ER) nurses' needs. You will analyze ER nurses' stories to:

- Identify functional needs (Lab #1)
- Identify usability needs (Lab #2)
- Identify a design opportunity & provide a rationale (Lab #3)
- **Create a conceptual design (Lab #4)**

INSTRUCTIONS FOR LAB #4

Step #1:

Open your Lab #1, Lab #2 & Lab #3 documents (i.e., participant transcripts, functional needs list, usability needs list & design rationale)

Step #2:

After reviewing your previous lab documents, create a conceptual design for the design opportunity you identified in Lab #3. Conceptual designs should consist of the following:

- List of functional needs that your design will address (i.e., subset of functional needs identified in Lab #1)
- List of usability needs that your design will address (i.e., subset of usability needs identified in Lab #2)
- Your conceptual design rationale (i.e., Lab #3)
- Mock-up(s) of your design with callouts to design features
- Scenario(s) of use
- Storyboard(s) which depict how your product will be used

Use the *Conceptual Design Template* & upload into VT Scholar by the due date designated in the syllabus.

C.5.10 Lab 4 Conceptual Design Template – Both Sections

Conceptual Design Template

Identified Design Opportunity:

[paragraph description of the design opportunity here. What problem do you intend to address with your project?]

Rationale:

[paragraph description of your rationale here. Why is this design opportunity important? Why did you select this opportunity over other possible design opportunities?]

Functional Needs Addressed by Design:

[bulleted list of functional needs here]

Usability Needs Addressed by Design:

[bulleted list of usability needs here]

Design Mock-up(s):

[pictures of design with call-outs to specific features]

Design Scenario(s):

[scenarios of use here]

Design Storyboards:

[storyboards of use here]

C.6 Demographic Questionnaire – Stakeholder Experts

Stakeholder Expert Demographic Questionnaire

Current Job Title: _____

Age: _____

Gender: Female Male

Please designate your years-of-experience in the following areas:

Healthcare _____ years-of-experience

Product design: _____ years-of-experience

Usability: _____ years-of-experience

Medical device design _____ years-of-experience

Requirements engineering _____ years-of-experience

By completing and submitting this questionnaire I agree to be part of the study.

C.7 Project Site for Stakeholder Experts

The screenshot shows the Virginia Tech Scholar interface. The top navigation bar includes the Virginia Tech logo (1872 Invent the Future) and the Scholar logo (a service of Learning Technologies). Below the navigation bar, the page is titled "My Workspace" and "Thematic Analysis Fall 2011". The main content area is titled "Stakeholder Expert Critiques".

On the left side, there is a navigation menu with the following items:

- Home
- Announcements
- Resources (highlighted)
- Site Info
- Help

The main content area is titled "Resources" and contains the following information:

Site Resources | Upload-Download Multiple Resources | Permis

Location: Stakeholder Expert Critiques Resources

Remove | Move | Copy

◆ [Title](#) ≡

- [Stakeholder Expert Critiques Resources](#)
- [Step 1: Review & Critique Conceptual Designs](#)
- [Team H - Patient information](#)
- [Team H Critique](#)
- [Team_H_Conceptual_Design.pdf](#)
- [Team F - RFID wristband](#)
- [Team C - Hospital Bed](#)
- [Team D - Med Wand](#)
- [Team B - Dosage Calculations](#)
- [Team E - Computer System](#)
- [Team G - Reduce Nurse Confusion](#)
- [Team A - Dosage Calculations](#)
- [Step 2: Rank Conceptual Designs](#)
- [Rankings](#)

C.8 Conceptual Design Critique Questionnaire

Conceptual Design Critique

Project Title: _____

Please indicate your agreement with the following statements regarding the apparent functionality and usability of the design:

FUNCTIONALITY:

1. The design addresses the identified functional need(s).

Strongly disagree *Disagree* *Neutral* *Agree* *Strongly agree*

2. The design DOES NOT address a “real-world” need within an ER setting:

Strongly disagree *Disagree* *Neutral* *Agree* *Strongly agree*

3. The design is an elegant solution to the identified problem.

Strongly disagree *Disagree* *Neutral* *Agree* *Strongly agree*

4. The conceptual design represents an innovative design solution.

Strongly disagree *Disagree* *Neutral* *Agree* *Strongly agree*

5. Critique of the design’s apparent functionality:

USABILITY:

6. The design DOES NOT address the identified usability need(s).

Strongly disagree *Disagree* *Neutral* *Agree* *Strongly agree*

7. Some of the design’s intended users would find it difficult to use.

Strongly disagree *Disagree* *Neutral* *Agree* *Strongly agree*

8. Users would prefer this design or solution to what is currently available.

Strongly disagree *Disagree* *Neutral* *Agree* *Strongly agree*

9. The design prevents users from making mistakes.

Strongly disagree *Disagree* *Neutral* *Agree* *Strongly agree*

10. Users would NOT be able to use this design quickly.

Strongly disagree Disagree Neutral Agree Strongly agree

11. This design does NOT require a lot of the user's resources to operate.

Strongly disagree Disagree Neutral Agree Strongly agree

12. Critique of the conceptual design's apparent usability:

13. The conceptual design is INAPPROPRIATE for use within an emergency room setting.

Strongly disagree Disagree Neutral Agree Strongly agree

14. Critique of the conceptual design's apparent appropriateness within an emergency room setting:

C.9 Conceptual Design Rankings Questionnaire

Conceptual Design Rankings

Now that you have completed your detailed critiques of each individual conceptual design, please rank each design in comparison with the other designs that you have critiqued. Ties between projects are not allowed.

Functionality: the design addresses ER workers' needs

(1=highest ranking, 8=lowest ranking):

| | |
|-------------------|-------|
| [Project Title A] | _____ |
| [Project Title B] | _____ |
| [Project Title C] | _____ |
| [Project Title D] | _____ |
| [Project Title E] | _____ |
| [Project Title F] | _____ |
| [Project Title G] | _____ |
| [Project Title H] | _____ |

Usability: the design's apparent ease-of-use:

(1=highest ranking, 8=lowest ranking):

| | |
|-------------------|-------|
| [Project Title A] | _____ |
| [Project Title B] | _____ |
| [Project Title C] | _____ |
| [Project Title D] | _____ |
| [Project Title E] | _____ |
| [Project Title F] | _____ |
| [Project Title G] | _____ |
| [Project Title H] | _____ |

The design's appropriateness within an ER setting:

(1=highest ranking, 8=lowest ranking):

| | |
|-------------------|-------|
| [Project Title A] | _____ |
| [Project Title B] | _____ |
| [Project Title C] | _____ |
| [Project Title D] | _____ |
| [Project Title E] | _____ |
| [Project Title F] | _____ |
| [Project Title G] | _____ |
| [Project Title H] | _____ |

C.11 Card sort instructions

USER NEEDS CARD SORT

Purpose:

The overall purpose of the card sort activity is to match up user needs with similar meanings. The **plain white card set** represent the “ideal” user needs set. A team of qualitative researchers identified these user needs from ER nurses’ interview transcripts. All of the other card sets represent user needs identified by a student team as part of a course project. For each project team card set, your goal is to match the project team’s cards with cards from the ideal set that have similar meanings from your perspective.

Background:

A **functional need** is defined as "WHAT the system or worker will do". A worker is any staff member involved in the Emergency Room (ER). A worker may be a nurse, a doctor, a lab tech, a triage nurse, a pharmacist, etc... .

A **usability need** is defined as "HOW the system or worker will do the functional need".

By design functional needs are much broader than usability needs. The rules for match-ups are slightly different depending on whether you are working with either the functional ideal set or the usability ideal set.

Functional match-up:

-the functional needs should be broad, as they are in the ideal set (I.e., "medicate patient"). However, many of the student teams’ functional needs are specific. In this case, you should match up a specific team need with a similar broad ideal set need. For example, if a student team had the need "hire guards", that could be matched up with the "protect patients" ideal card. So for the functional set, it is ok to match specific student team cards with broad ideal cards.

Usability match-up:

-both the ideal and student team cards should be specific, so these should be more of a 1-to-1 matching. So if the ideal card was "protect patients", I would not match "hire guards" to the "protect patients" ideal card.

CONDUCTING THE SORT:

1. FUNCTIONAL BAG

Contents: identified “functional” needs

ideal user needs set: plain white cards bundle

10 Project team sets: all other bundles **(PLEASE DO IN THIS ORDER)**

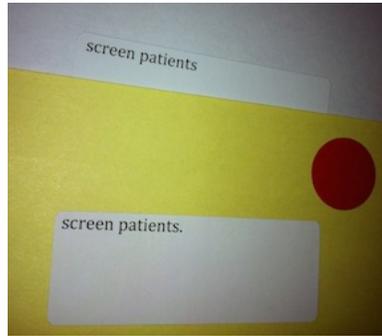
1. White & orange dot
2. White & red dot
3. Blue
4. Pastel green
5. Neon green
6. White & Orange/red dot
7. Neon pink
8. Yellow + red dot
9. Yellow
10. Purple

1. Spread out white cards on a large table or on the floor.

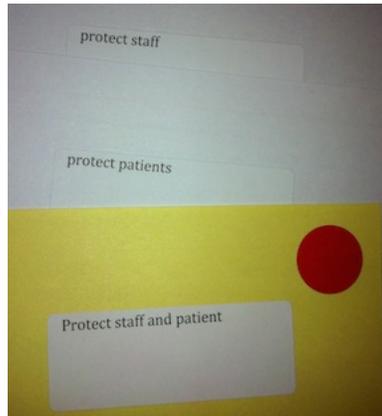


2. For EACH bundle of colored cards (e.g., yellow + red dot, purple, green, etc....):
 - a. Remove & read a card one at a time from current colored stack (e.g., yellow + red dot)
 - b. If the meaning of the colored card **matches** a white card, place the colored card on top of the white card
 - i. **NOTE: not all cards will have a match**

ii. Some will have an exact match



iii. Some will match more than 1 ideal card



iv. Some will match according to your individual interpretation



- c. If the meaning of the colored card does not match a white card, place it to the side in a pile.
- d. Repeat until there are no cards in the current stack

- i. Record matches in the Excel file

| IDEAL SET (PLAIN WHITE CARDS) | STUDENT PROJECT TEAMS |
|--------------------------------|---------------------------|
| | YELLOW + RED DOT |
| double check calculations | double check dosage |
| double check staff | |
| draw blood | |
| educate patients | |
| educate staff | |
| eliminate double documentation | |
| explain home care | |
| find equipment | |
| follow procedures | enforce proper procedures |
| ID patients | verify correct patient |
| identify allergies | |
| intervene crisis situation | |
| label medications | |
| lay out hospital | |
| lock doors | protect front door |

- ii. Bundle unmatched cards using rubber band and UNMATCHED paper marker.
- iii. Collect colored matched cards and bundle using rubber band and MATCHED paper marker



- iv. Return white cards to the table or floor
- e. Repeat with new bundle of colored cards & repeat until you have worked through all of the colored bundles.

USABILITY BAG:

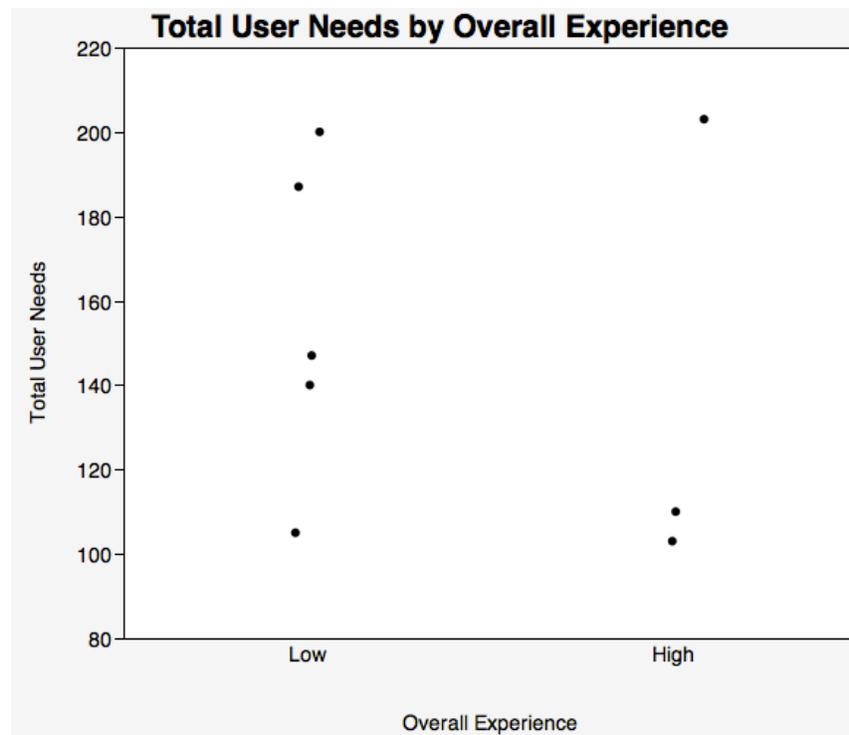
-follow functional instructions, but record on the USABILITY tab in Excel.

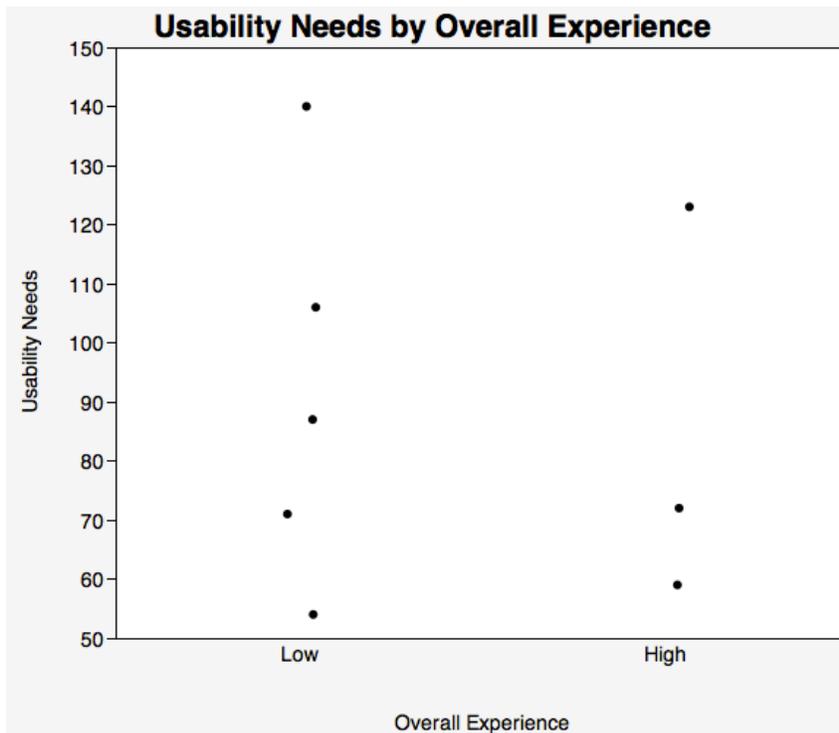
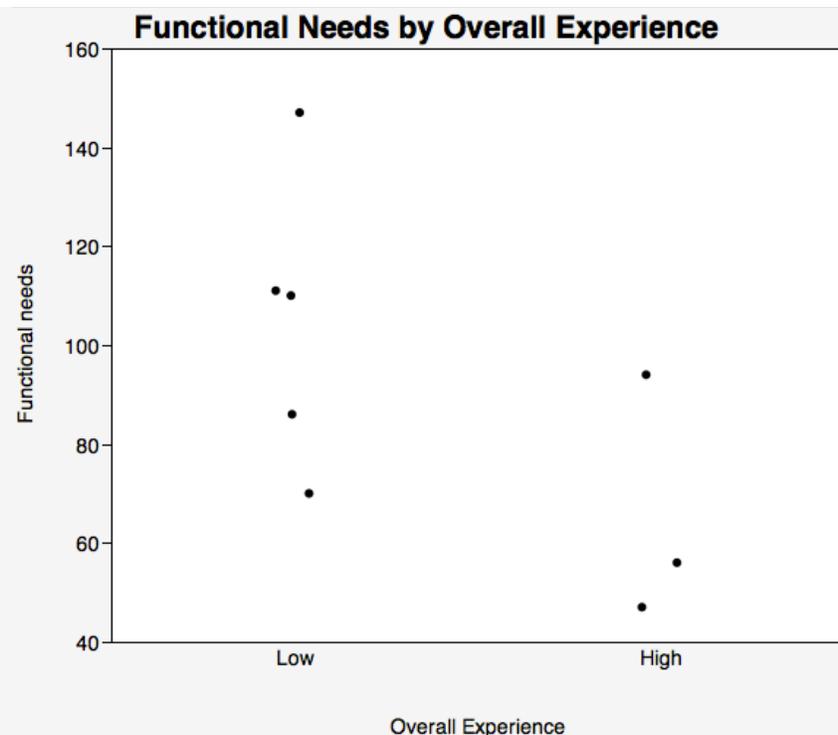
C.11 Phase 3 SAS commands & output

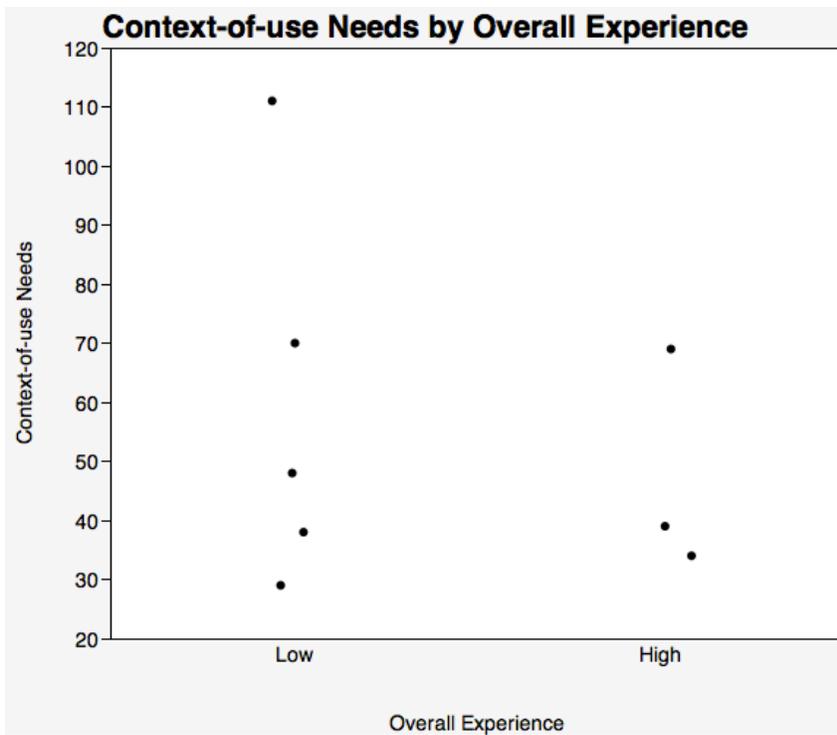
C.11.1 RQ2a boxplots

```
proc boxplot;  
title 'Box Plot for User Needs Identified by Group';  
plot Needs*Treatment_Name /  
symbollegend = legend1;  
label Needs = 'Mean Needs Identified';  
label Treatment_Name = "Design Group";  
run;
```

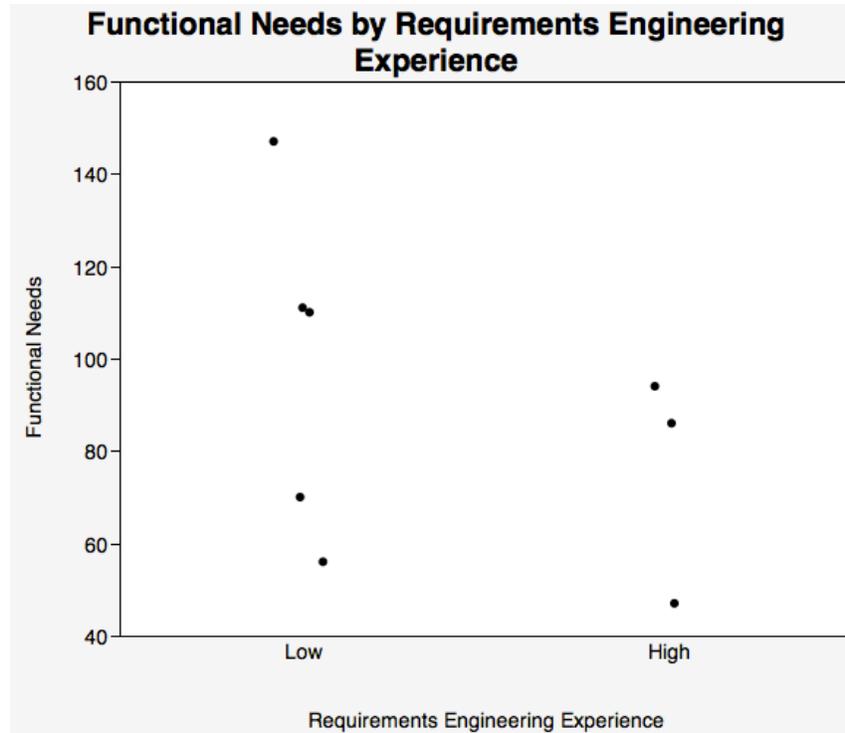
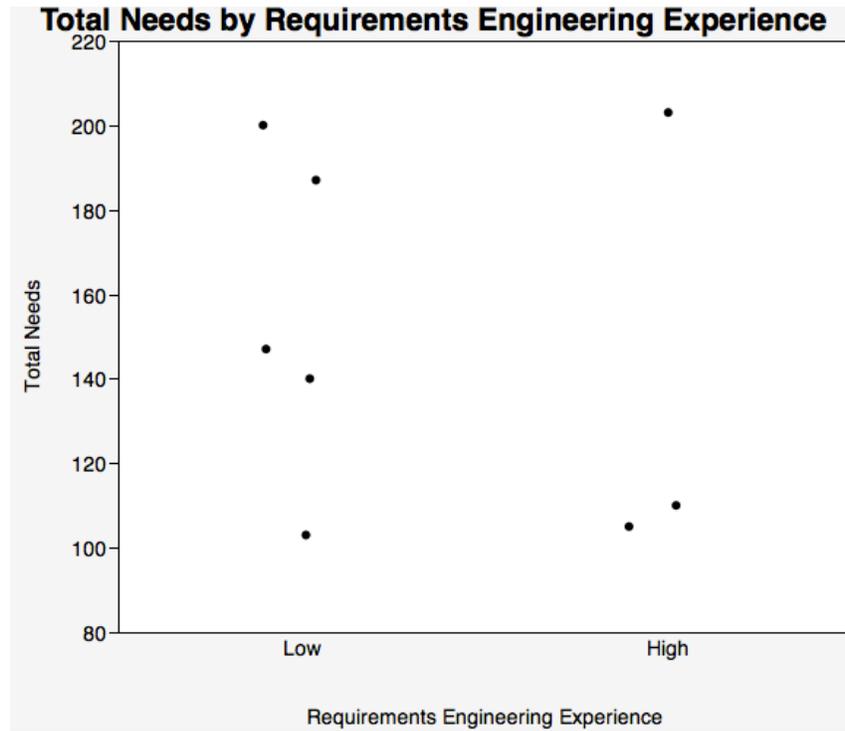
C.11.1.1 Overall Experience

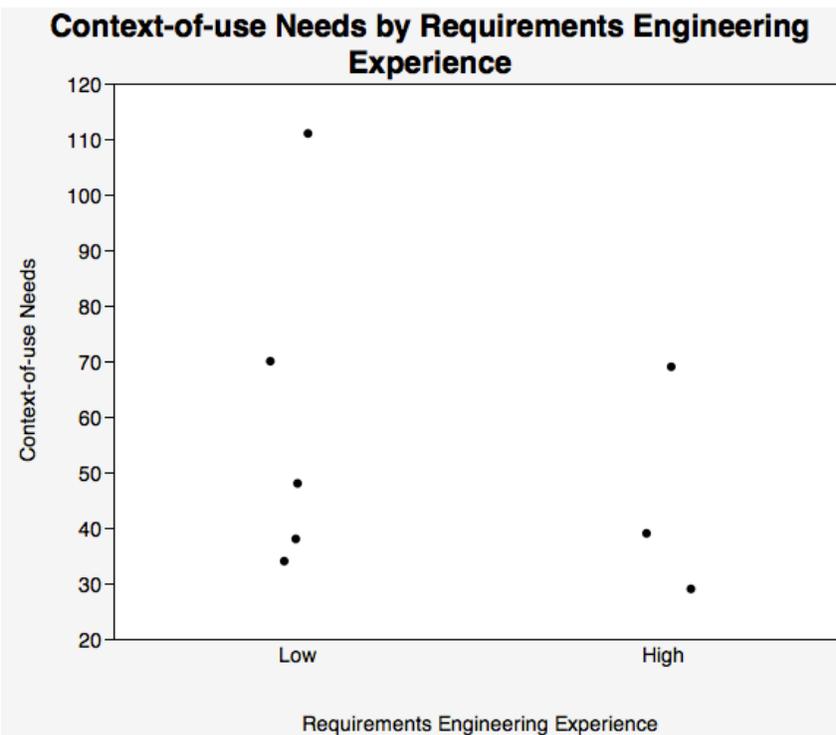
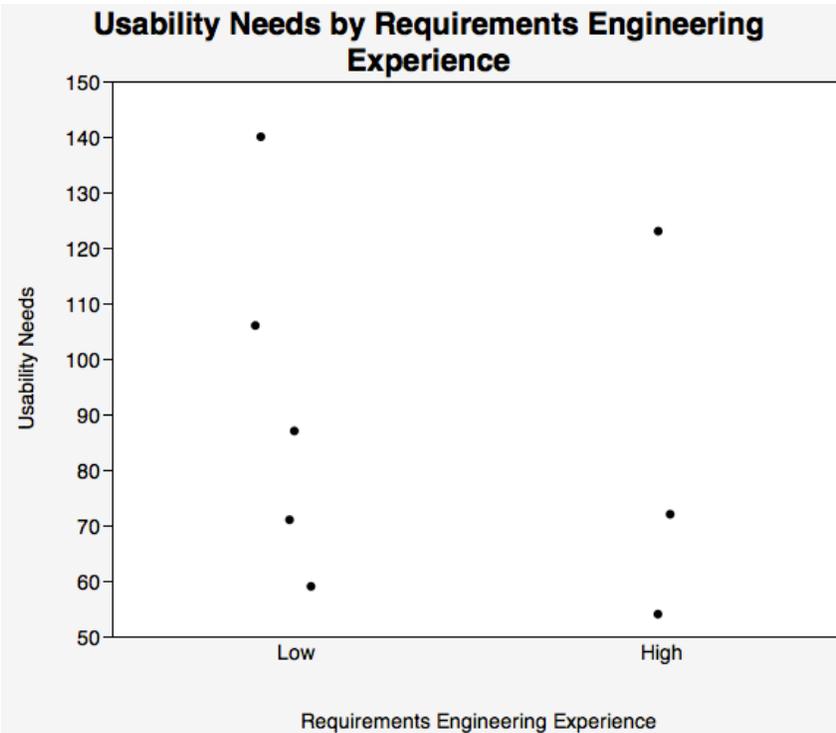




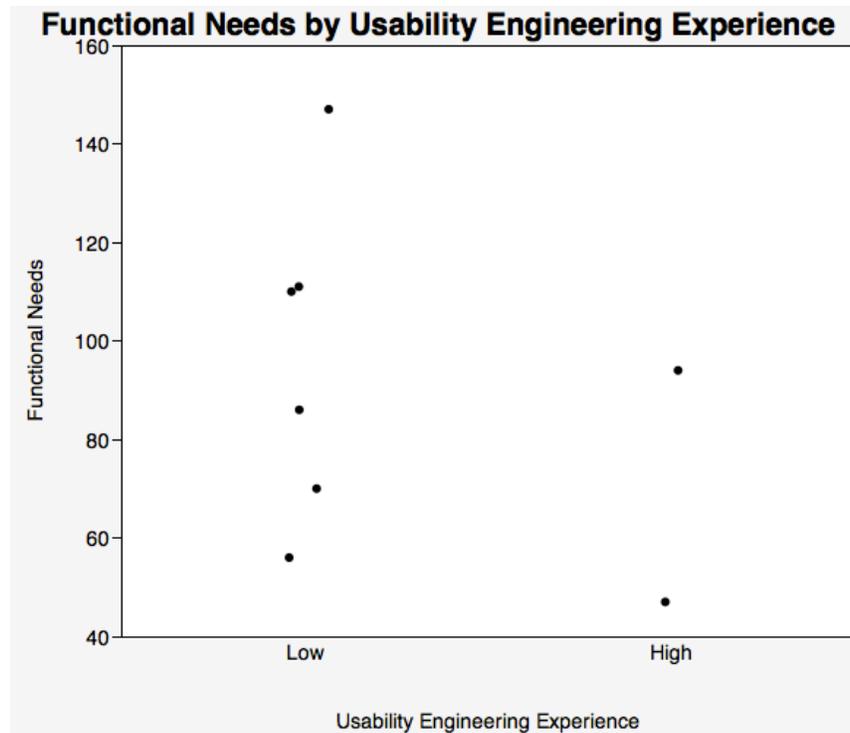
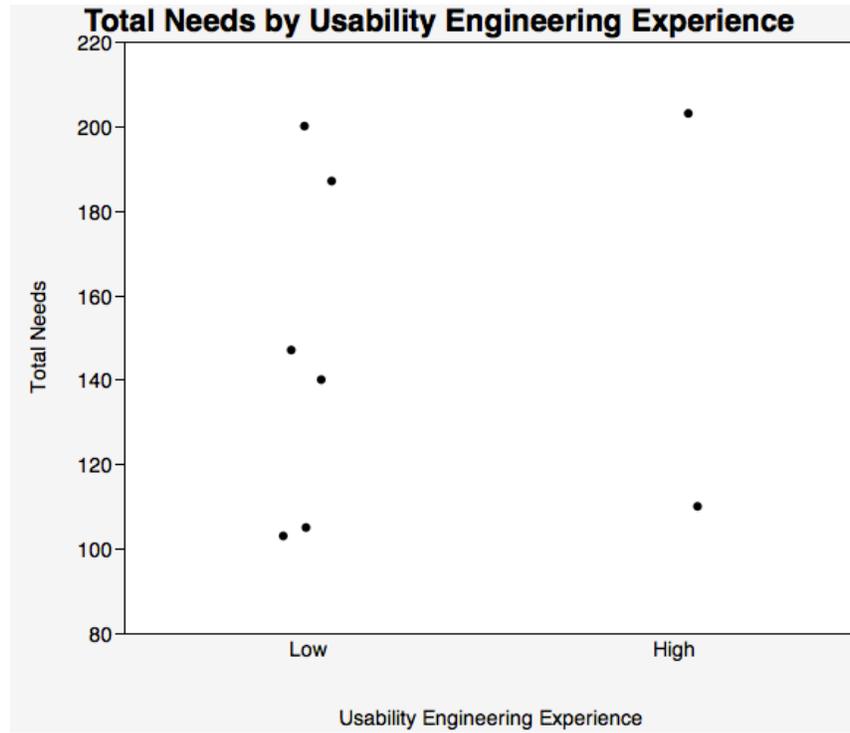


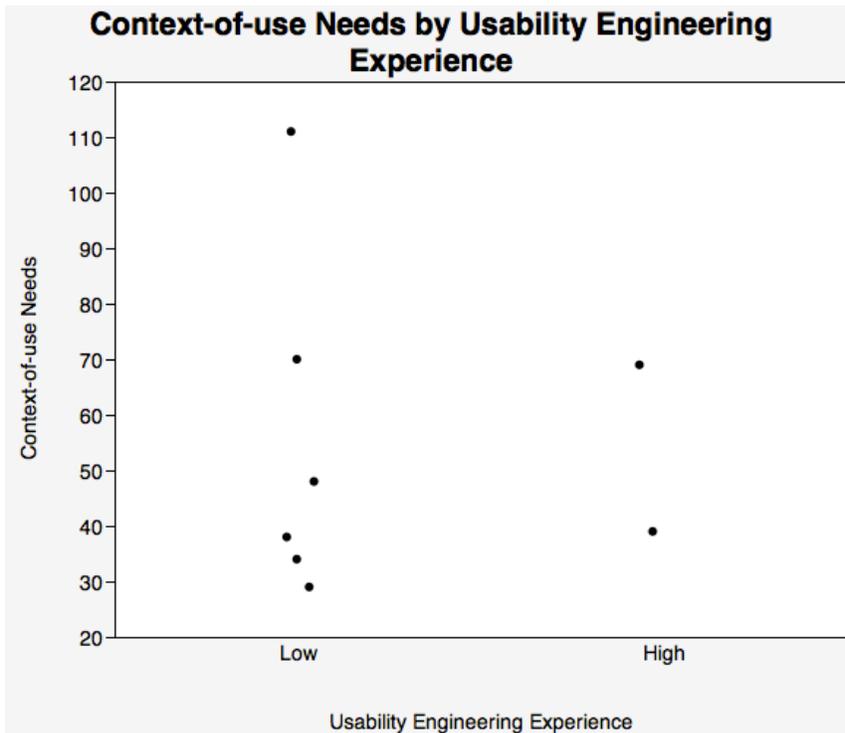
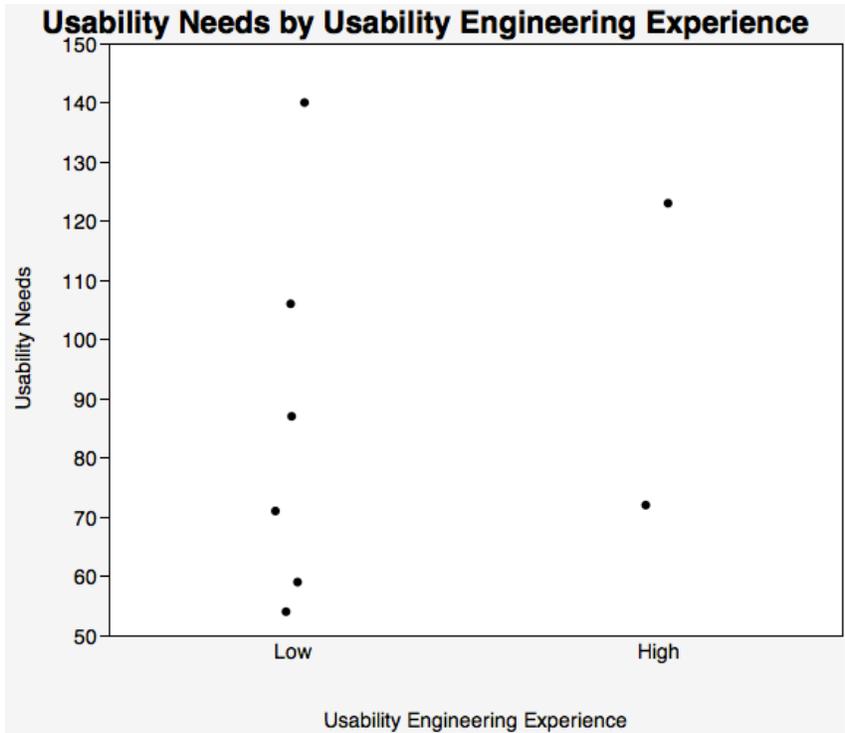
C.11.1.2 Requirements Engineering Experience



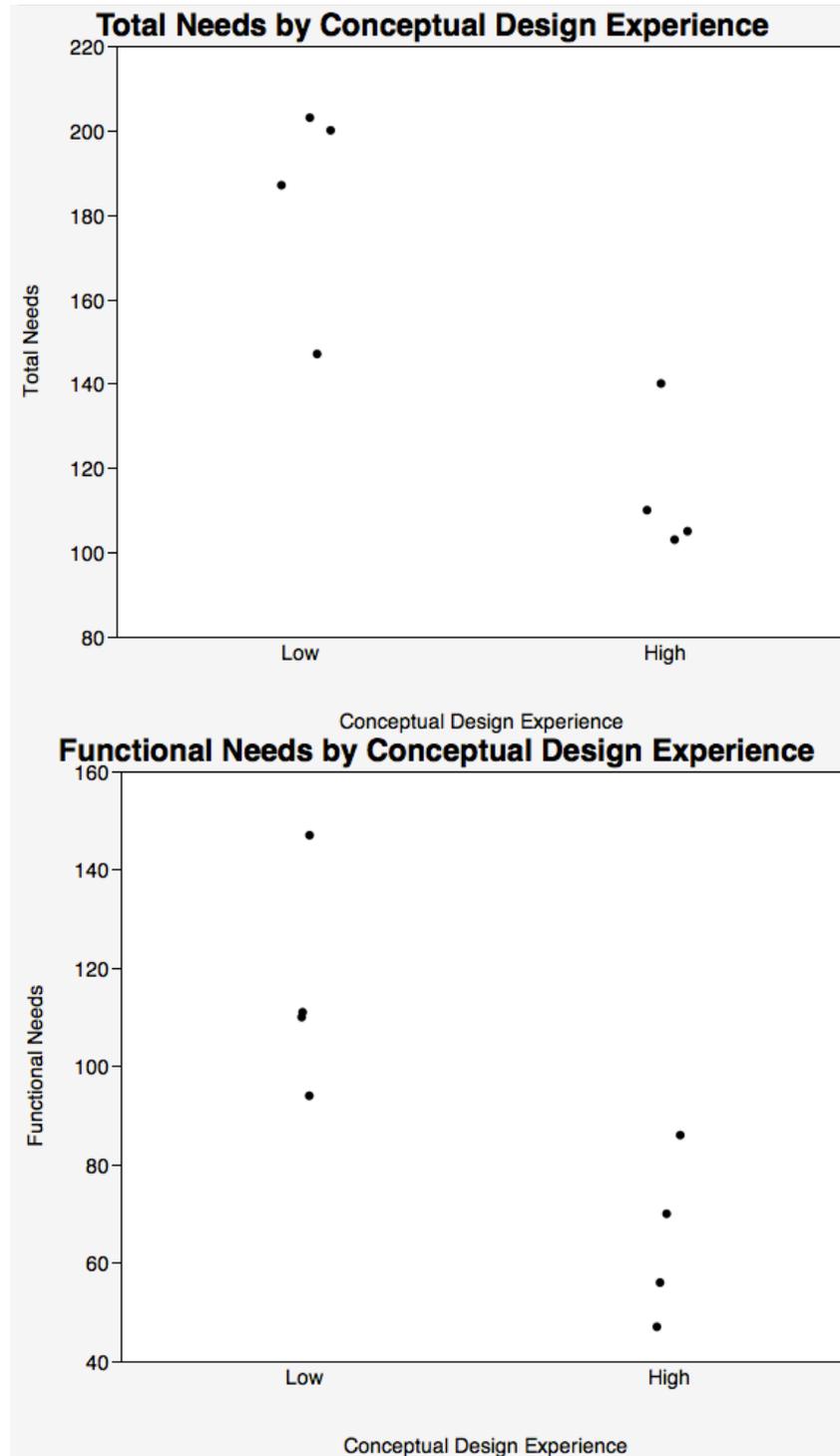


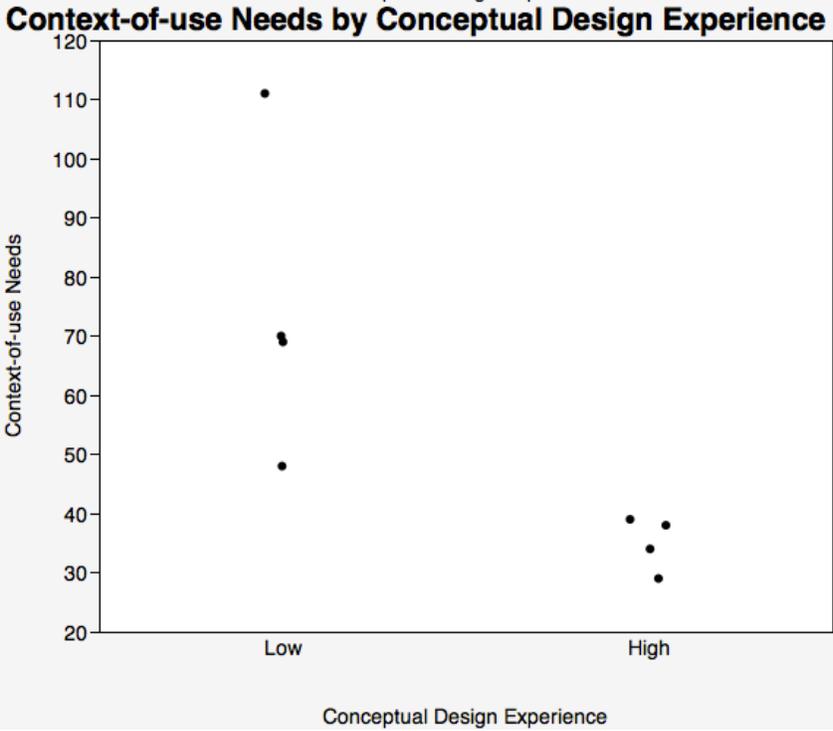
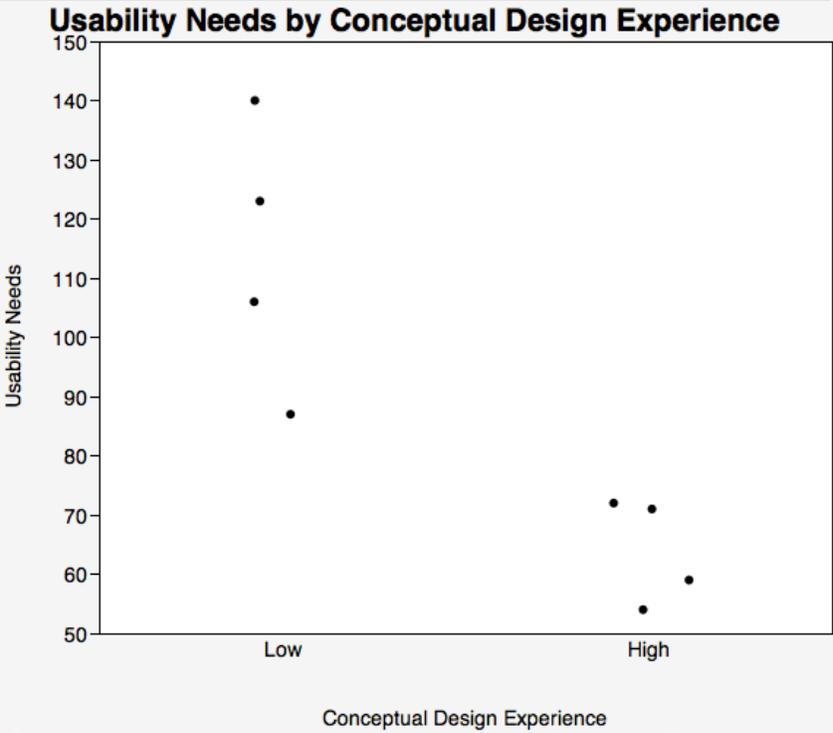
C.11.1.3 Usability Engineering Experience



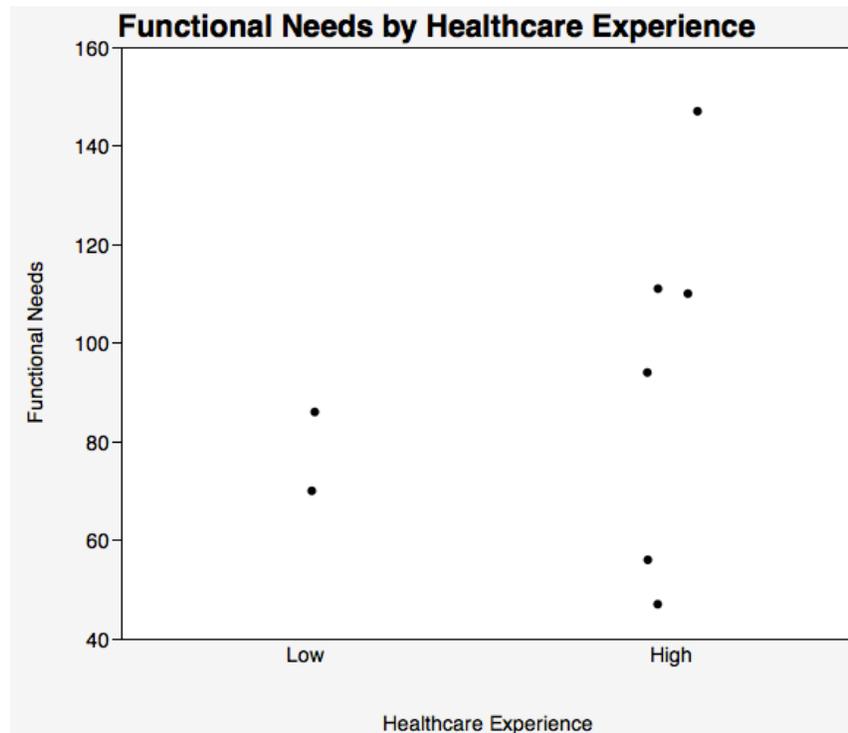
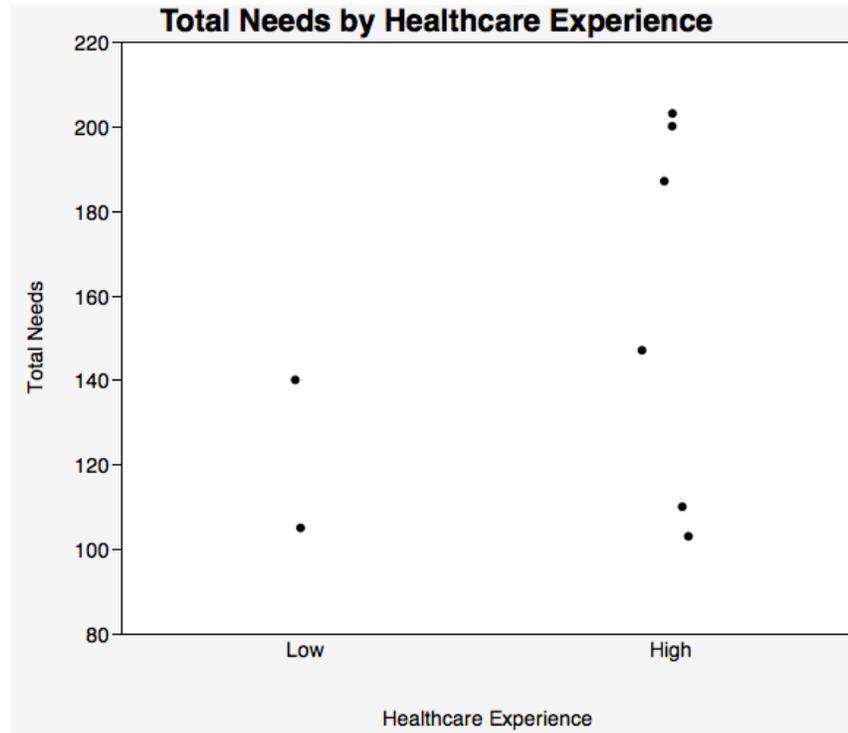


C.11.1.4 Conceptual Design Experience

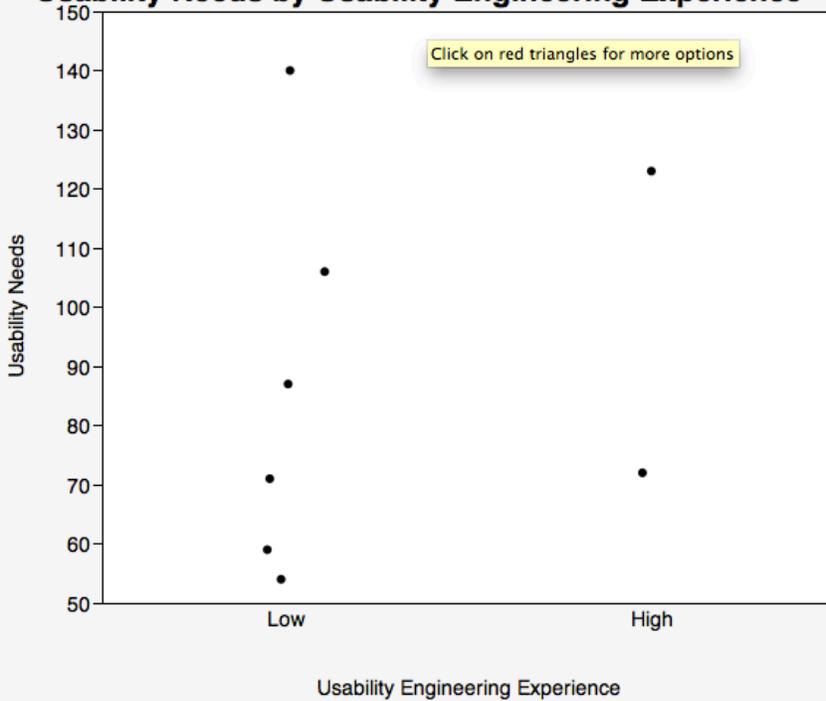




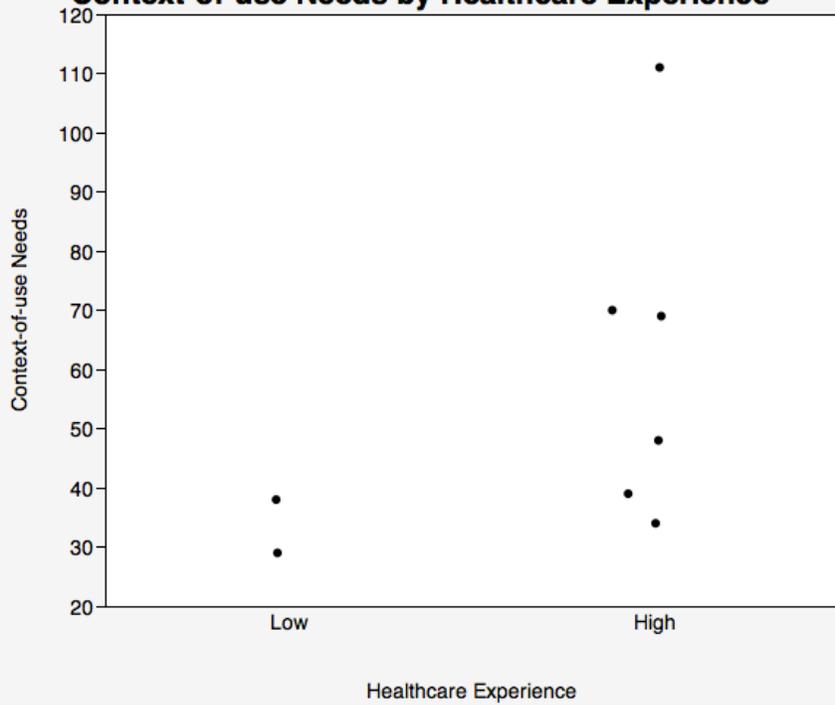
C.11.1.5 Healthcare Experience



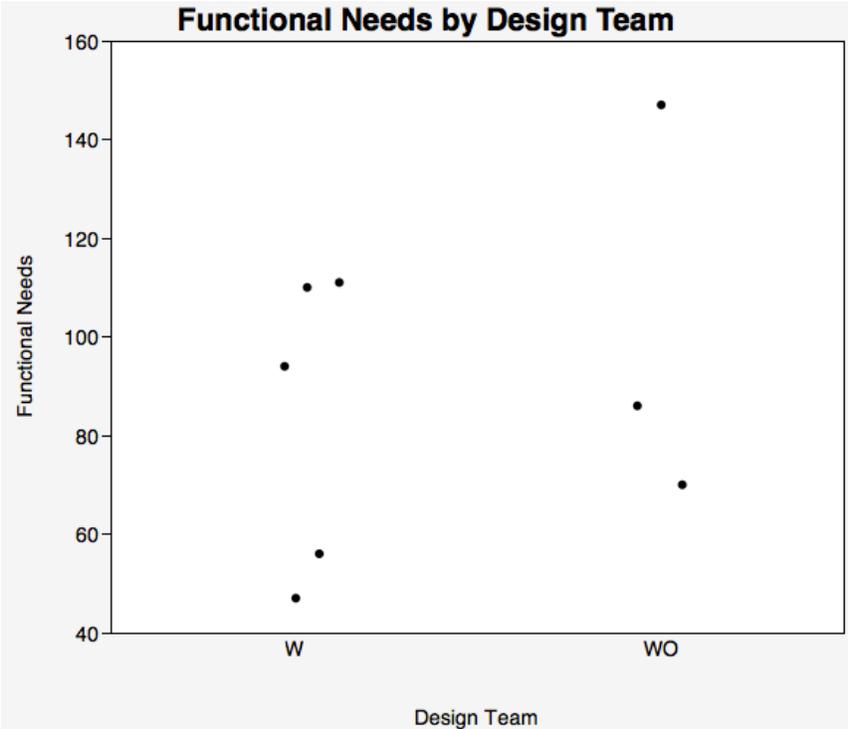
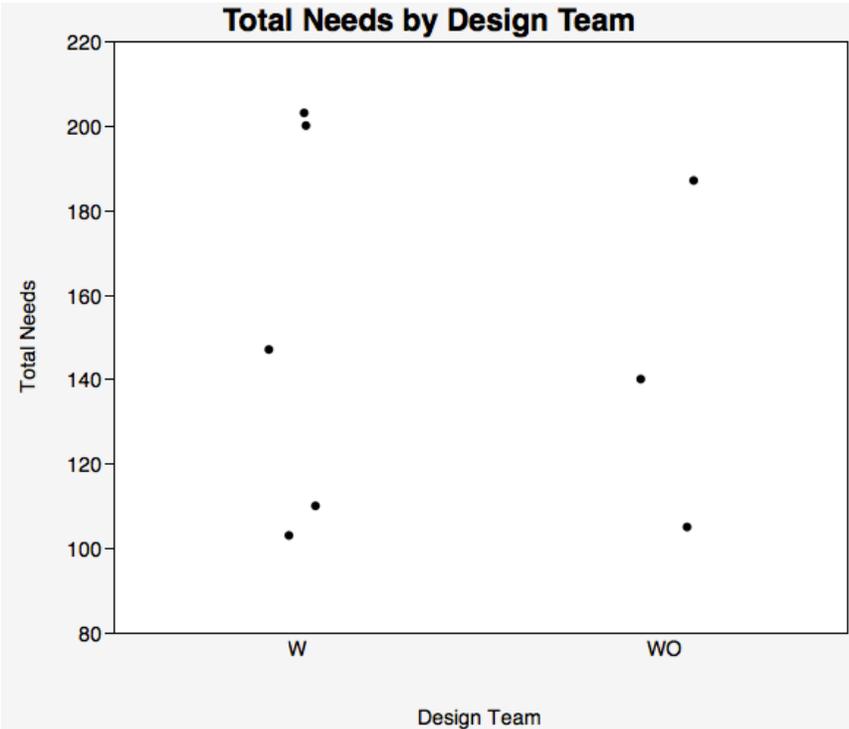
Usability Needs by Usability Engineering Experience



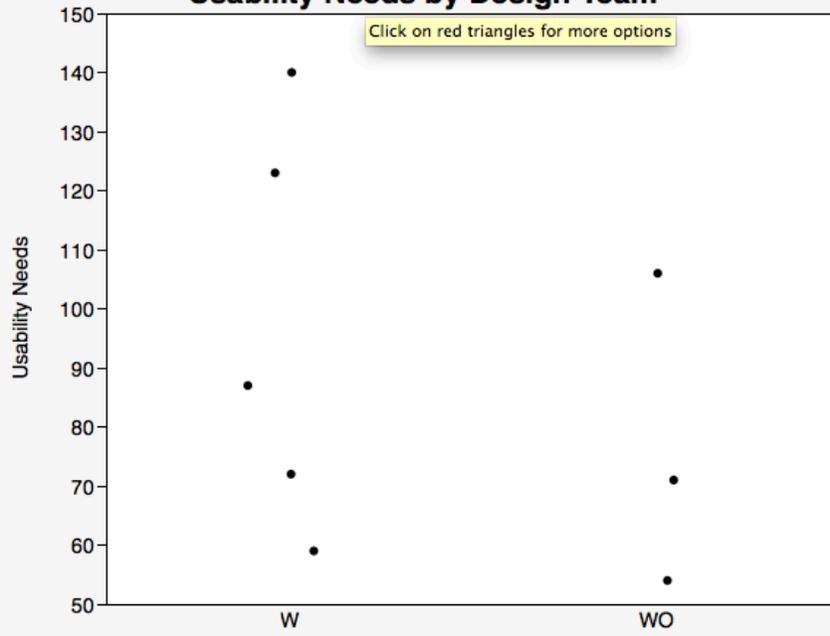
Context-of-use Needs by Healthcare Experience



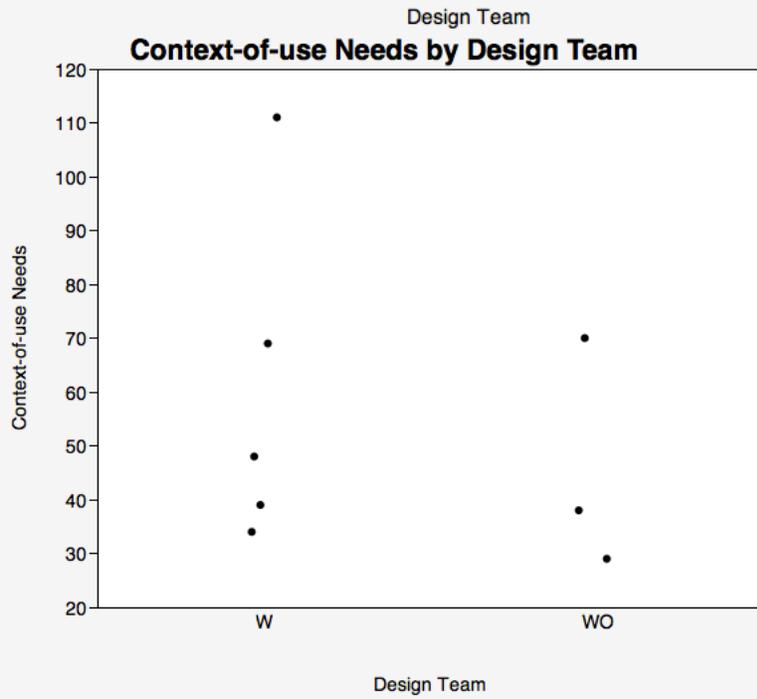
C.11.1.6 Treatment Group



Usability Needs by Design Team



Context-of-use Needs by Design Team



C 11.2 RQ2b SAS code and output

C.11.2.1 Validation of questionnaire items

```
proc corr alpha;
title "FUNCTIONALITY ITEM ANALYSIS";
var Q3_1_1 Q3_1_2_REVERSE Elegance_question Q3_1_4;
run;
```

Functionality item analysis

| Cronbach Coefficient Alpha | | | | |
|----------------------------|----------|--|--|--|
| Variables | Alpha | | | |
| Raw | 0.848820 | | | |
| Standardized | 0.849530 | | | |

| Cronbach Coefficient Alpha with Deleted Variable | | | | |
|--|------------------------|----------|------------------------|----------|
| Deleted Variable | Raw Variables | | Standardized Variables | |
| | Correlation with Total | Alpha | Correlation with Total | Alpha |
| Q3_1_1 | 0.625261 | 0.835071 | 0.631061 | 0.832910 |
| Q3_1_2_REVERSE | 0.672949 | 0.815067 | 0.672608 | 0.815540 |
| Elegance_question | 0.705670 | 0.800044 | 0.703571 | 0.802332 |
| Q3_1_4 | 0.751541 | 0.779638 | 0.747678 | 0.783125 |

Usability item analysis

| Cronbach Coefficient Alpha | | | | |
|----------------------------|----------|--|--|--|
| Variables | Alpha | | | |
| Raw | 0.853186 | | | |
| Standardized | 0.856580 | | | |

| Cronbach Coefficient Alpha with Deleted Variable | | | | |
|--|------------------------|----------|------------------------|----------|
| Deleted Variable | Raw Variables | | Standardized Variables | |
| | Correlation with Total | Alpha | Correlation with Total | Alpha |
| Q8_1_1_REVERSE | 0.736590 | 0.812839 | 0.727867 | 0.817018 |
| Q8_1_2_REVERSE | 0.678576 | 0.821705 | 0.690378 | 0.824134 |
| Q8_1_3 | 0.569835 | 0.841990 | 0.578408 | 0.844749 |
| Q8_1_4 | 0.688062 | 0.821256 | 0.689462 | 0.824307 |
| Q8_1_5_REVERSE | 0.639732 | 0.829886 | 0.622423 | 0.836759 |
| Q8_1_6 | 0.565440 | 0.842448 | 0.563840 | 0.847362 |

C 11.2.1 Two-sample t-tests for experts' rankings

```
proc freq;
title "Friedman test - FUNCTIONALITY";
tables REVIEWER*Group*Functionality_rank / cmh2 scores=rank;
tables REVIEWER*Design_Experience*Functionality_rank / cmh2 scores=rank;
tables REVIEWER*Requirements_Experience*Functionality_rank / cmh2 scores=rank;
tables REVIEWER*Usability_Experience*Functionality_rank / cmh2 scores=rank;
tables REVIEWER*Conceptual_Design_Experience*Functionality_rank / cmh2 scores=rank;
tables REVIEWER*Healthcare_Experience*Functionality_rank / cmh2 scores=rank;
tables REVIEWER*Overall_Experience*Functionality_rank / cmh2 scores=rank;
run;
```

Test for differences in overall rankings between groups of low & high design experience

The FREQ Procedure

Summary Statistics for Design_Experience by Overall_rank
Controlling for REVIEWER

Cochran-Mantel-Haenszel Statistics (Based on Rank Scores)

| Statistic | Alternative Hypothesis | DF | Value | Prob |
|-----------|------------------------|----|--------|--------|
| 1 | Nonzero Correlation | 1 | 4.6296 | 0.0314 |
| 2 | Row Mean Scores Differ | 1 | 4.6296 | 0.0314 |

Total Sample Size = 24

Test for differences in overall rankings between groups of low & high conceptual design experience

The FREQ Procedure

Summary Statistics for Conceptual_Design_Experience by Overall_rank
Controlling for REVIEWER

Cochran-Mantel-Haenszel Statistics (Based on Rank Scores)

| Statistic | Alternative Hypothesis | DF | Value | Prob |
|-----------|------------------------|----|--------|--------|
| 1 | Nonzero Correlation | 1 | 4.0000 | 0.0455 |
| 2 | Row Mean Scores Differ | 1 | 4.0000 | 0.0455 |

Total Sample Size = 24

Test for differences in functionality rankings between groups of low & high conceptual design experience

The FREQ Procedure

Summary Statistics for Conceptual_Design_Experience by Functionality_rank
Controlling for REVIEWER

Cochran-Mantel-Haenszel Statistics (Based on Rank Scores)

| Statistic | Alternative Hypothesis | DF | Value | Prob |
|-----------|------------------------|----|--------|--------|
| 1 | Nonzero Correlation | 1 | 3.3611 | 0.0668 |
| 2 | Row Mean Scores Differ | 1 | 3.3611 | 0.0668 |

Total Sample Size = 24

Test for differences in usability rankings between groups of low & high conceptual design experience

The FREQ Procedure

Summary Statistics for Conceptual_Design_Experience by Usability_rank
Controlling for REVIEWER

Cochran-Mantel-Haenszel Statistics (Based on Rank Scores)

| Statistic | Alternative Hypothesis | DF | Value | Prob |
|-----------|------------------------|----|--------|--------|
| 1 | Nonzero Correlation | 1 | 2.7778 | 0.0956 |
| 2 | Row Mean Scores Differ | 1 | 2.7778 | 0.0956 |

Total Sample Size = 24

Test for differences in functionality rankings between groups of low & high healthcare experience

The FREQ Procedure

Summary Statistics for Healthcare_Experience by Functionality_rank
Controlling for REVIEWER

Cochran-Mantel-Haenszel Statistics (Based on Rank Scores)

| Statistic | Alternative Hypothesis | DF | Value | Prob |
|-----------|------------------------|----|--------|--------|
| 1 | Nonzero Correlation | 1 | 4.4815 | 0.0343 |
| 2 | Row Mean Scores Differ | 1 | 4.4815 | 0.0343 |

Total Sample Size = 24

Test for differences in usability rankings between groups of high & low healthcare experience

The FREQ Procedure

Summary Statistics for Healthcare_Experience by Usability_rank
Controlling for REVIEWER

Cochran-Mantel-Haenszel Statistics (Based on Rank Scores)

| Statistic | Alternative Hypothesis | DF | Value | Prob |
|-----------|------------------------|----|--------|--------|
| 1 | Nonzero Correlation | 1 | 3.0000 | 0.0833 |
| 2 | Row Mean Scores Differ | 1 | 3.0000 | 0.0833 |

Total Sample Size = 24

Test for differences in elegance questionnaire responses between WO and W teams

The FREQ Procedure

**Summary Statistics for Group by Elegance_question
Controlling for REVIEWER**

Cochran-Mantel-Haenszel Statistics (Based on Rank Scores)

| Statistic | Alternative Hypothesis | DF | Value | Prob |
|------------------|-------------------------------|-----------|--------------|-------------|
| 1 | Nonzero Correlation | 1 | 2.8586 | 0.0909 |
| 2 | Row Mean Scores Differ | 1 | 2.8586 | 0.0909 |

Total Sample Size = 24

Test for differences in innovative questionnaire responses between WO and W teams

The FREQ Procedure

**Summary Statistics for Group by Innovative_question
Controlling for REVIEWER**

Cochran-Mantel-Haenszel Statistics (Based on Rank Scores)

| Statistic | Alternative Hypothesis | DF | Value | Prob |
|------------------|-------------------------------|-----------|--------------|-------------|
| 1 | Nonzero Correlation | 1 | 2.8203 | 0.0931 |
| 2 | Row Mean Scores Differ | 1 | 2.8203 | 0.0931 |

Total Sample Size = 24

C 11.2.1 inter-rater reliability for experts' statements

```
proc freq;  
tables rater1*rater2 / agree;  
test kappa;  
run;
```

Simple Kappa Coefficient

| | |
|----------------------|--------|
| Kappa | 0.7936 |
| ASE | 0.0532 |
| 95% Lower Conf Limit | 0.6893 |
| 95% Upper Conf Limit | 0.8979 |

Test of H0: Kappa = 0

| | |
|-------------------|---------|
| ASE under H0 | 0.0580 |
| Z | 13.6923 |
| One-sided Pr > Z | <.0001 |
| Two-sided Pr > Z | <.0001 |

Weighted Kappa Coefficient

| | |
|----------------------|--------|
| Weighted Kappa | 0.8501 |
| ASE | 0.0465 |
| 95% Lower Conf Limit | 0.7589 |
| 95% Upper Conf Limit | 0.9413 |

Sample Size = 74

APPENDIX D: Glossary of Terms

| Term | Operational definition |
|--------------------------|---|
| abstract | a summative statement; one of Labov & Waletzky's (1967) optional structural components found within a narrative. |
| activity need | describes the context of the activity, such as: -distractions & other tasks that may interfere -surprise/startle effect -strain & stress -influence on the working environment (e.g., not able to hear patient over noise) -workload & fatigue (IEC, 2007) |
| breadth of user need set | proportional measure of the number of categories discussed in comparison to the total number of possible user need categories; $\text{breadth} = \frac{\# \text{ categories discussed}}{\text{total \# categories}}$ |
| complicating action | the plot; the only non-optional structural component (Labov & Waletzky, 1967). Complicating actions describe a temporal sequence of event(s), a conflict, or highlight a cause within a cause/effect relationship. |
| context-of-use need | describes "the users, tasks, equipment, and environments" for a problem and/or solution (ISO, 1999); context-of-use needs in healthcare describe the activity, hygienic, physical, social, spatial, or technological context (IEC, 2007) |
| depth of user need set | the quantity of user needs elicited within a particular category of interest (e.g., 7 functional needs identified) |
| distinct user need | a unique user need; only counted once in calculations for the quantity of user needs elicited. |
| effective care | care which provides "services based on scientific knowledge to all who could benefit" and refrains "from providing services to those not likely to benefit" (IOM, 2001); one of 6 healthcare quality aims identified by the Institute of Medicine |

| | |
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| | (IOM). |
| effectiveness need | describes the level of accuracy and completeness in which a user is able to satisfy goals |
| efficient care | care which reduces “waste, including waste of equipment, supplies, ideas, and energy” (IOM, 2001); one of 6 healthcare quality aims identified by the Institute of Medicine (IOM). |
| efficiency need | describes the amount of resources used to achieve goals |
| equitable care | care “that does not vary in quality because of personal characteristics such as gender, ethnicity, geographic location, and socioeconomic status” (IOM, 2001); one of 6 healthcare quality aims identified by the Institute of Medicine (IOM). |
| evaluation | reflective statements, such as opinions of events, which highlight why the story was told; one of Labov & Waletzky’s (1967) optional structural components. |
| functional need | states what the worker or system needs to do. In general, functional needs are stated to fit the format “the worker shall.....” or “the system shall...” |
| habitual narrative | a representation of personal experience formed by content and structure; habitual narratives are analyzed versions of habitual stories |
| habitual story | a free-form representation of personal experience |
| hygienic need | describes the design requirements for sterile conditions, cleaning, and waste disposal (IEC, 2007) |
| hypothetical narrative | a representation of a fictional and idealized version of a personal experience, which is formed by content and structure; hypothetical narratives are analyzed versions of hypothetical stories |
| hypothetical story | a free-form representation of a fictional and idealized version of a personal experience |

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| Institute of Medicine (IOM) quality aims | 6 identified measures of healthcare quality: effective care, efficient care, equitable care, patient-centered care, safe care, and timely care |
| narrative | a representation of personal experience (i.e., a story) formed by content and structure |
| narrative analysis | process of transforming participant stories into concise narratives using Labov & Waletzky's (1967) structural components (e.g., abstract, orientation, complicating action, resolution evaluation); analysis approach used in Phase 1 |
| orientation | contextual information, such as an event background description and/or a description of the setting and character(s); one of Labov & Waletzky's (1967) optional structural components found within a narrative. |
| patient-centered care | care which is "respectful of and responsive to individual patient preferences, needs, and values" and ensures "that patient values guide all clinical decisions" (IOM, 2001); one of 6 healthcare quality aims identified by the Institute of Medicine (IOM). |
| physical need | describes aspect of the physical environment, such as climate conditions, light levels, and noise levels. (IEC, 2007) |
| phrase | a statement preceding a phrase break, such as the words 'and', 'so', 'but', and punctuation, such as commas, ellipses, and dashes; the unit of analysis for structural analysis |
| quantity of user needs | the number of distinct user needs contributed per participant |
| quality of user needs | a measure of the breadth and depth of the user needs set |
| resolution | the result of the complicating action; one of Labov & Waletzky's (1967) optional structural components found within a narrative. |
| robustness of a user need set | a combined measure of the quantity and quality of a user need set |

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| safe care | care which prevents “injures to patients from the care that is intended to help them” (IOM, 2001); one of 6 healthcare quality aims identified by the Institute of Medicine (IOM). |
| satisfaction need | describes the perceived comfort level and acceptability while working towards goals |
| social need | describes aspects of the social organization, such as: -transition of care -who is around (e.g., children, family, etc...) -responsibility (e.g., shared vs. alone) (IEC, 2007) |
| spatial need | describes aspects of the location in the design problem and/or solution, such as: -architecture -patient transport (IOM, 2007) |
| story | a free-form representation of personal experience |
| technological need | describes other technologies or devices involved in design problem and/or solution |
| thematic analysis | use of constant comparisons to identify themes within text (Gribich, 2007); analysis method for Phase 2 |
| timely care | care which reduces “waits and sometimes harmful delays for both those who receive and those who give care” (IOM, 2001); one of 6 healthcare quality aims identified by the Institute of Medicine (IOM). |
| usability needs | the set of effectiveness, efficiency, satisfaction, and context-of-use needs (i.e., activity, hygienic, physical, social, spatial, technological) |
| user need | description of general or specific characteristics of the design problem that must be accounted for in the development of the design solution. (based on ANSI/AAMI (2001) definition of requirement); the precursor to a requirement |