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Cub Companion

PROJECT REPORT

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ABSTRACT

Each year, over 40,000 children undergo cancer treatments ("Childhood Cancer Statistics | CureSearch," 2019). These treatments and the associated "new normal" cause stress for the patients. The effect of this stress can cause negative long- and short-term physical and psychological consequences, such as longer hospital stays and refusal to seek medical treatment in the future. To prevent these consequences, it is vital to alleviate as much stress as possible during pediatric cancer treatments. Preliminary research has suggested that education, distraction techniques, and breathing exercises may be beneficial to children during these procedures.

To evaluate the best method for alleviating stress and anxiety during cancer treatments, the Cub Companion team interviewed two pediatric nurses and six parents of children with childhood cancer diagnoses. Using the information gathered, a qualitative content analysis was conducted using pre-coded themes to determine prevalent ideas throughout the interviews. Themes emerged of trust with parents and medical staff, comfort in a new environment, and distraction during invasive procedures.

These results aided the team in creating an updated Cub Companion concept. A customizable physical bear may be scanned into a virtual world in a mobile application. In this virtual world, the child's bear may interact with representations of their real-life nurses and play games to build trust and provide distraction. This concept was tested with a low-fidelity paper prototype, and with feedback, a medium-fidelity Adobe XD prototype was created. After preliminary user testing, the virtual world shows promise for being capable of providing distraction and helping the child build trust with medical personnel.

INTRODUCTION

Each day, 43 children are diagnosed with cancer, and around 40,000 children undergo some type of cancer treatment ("Childhood Cancer Statistics | CureSearch," 2019). The stress associated with the diagnosis and treatments can cause negative physical and psychological effects, such as longer hospital stays and refusal to seek medical treatment in the future. To prevent these consequences, it is vital to alleviate as much stress as possible during pediatric cancer treatments. Thus, the concept of Cub Companion was born.

The original idea for this project came from a team of undergraduate Pennsylvania State University technology and nursing students who won an mHealth competition. Based on this team's interviews with child life specialists, the first concept aimed to combine a physical teddy bear with a Bluetooth speaker controlled by a mobile application. A parent or medical professional may select from three non-physical functions including education, breathing exercises, and distraction techniques from the mobile application. The goal of the current team was to conduct interviews with parents of pediatric cancer patients and pediatric nurses to determine the best methods for alleviating the stress associated with

childhood cancer treatments. Based on the conclusions drawn from interviews, a medium-fidelity prototype was to be created and tested.

RELATED WORK

Previous research for this project was focused on hospital personnel; many interviews were conducted with child life specialists. Child life specialists aim to provide the pediatric patient with items of distraction and comfort during their treatments. In order to expand on this information and narrow down a target audience for Cub Companion, the team needed to conduct more interviews with a broader audience and perform some preliminary research on the topic at hand. The team focused their investigation on the topics of psychological aspects of children undergoing treatment, existing products on the market in this design space, "kid speak" and how to communicate effectively with children, and how children interact with products. Through this research, the team aimed to understand what void Cub Companion can fill in the current treatment of pediatric cancer patients.

Psychological Aspects

In order to determine how to reduce stress and anxiety in pediatric cancer patients, knowledge on the psychology of children and child patients needs to be taken into consideration. Continuing off of prior research, the team has found studies relating to children's overall experiences within hospitals and some common methods of coping. When hospitalized, children have a range of worries and stressors. Two high-level issues that children tend to have are being separated from those they are familiar with, and being in an unfamiliar place (Coyne, 2006). These can include disruption to school achievement along with not knowing the hospital staff that is always around them (Coyne, 2006). Another study points at "active distraction" as a coping method that engages them in an activity that distracts them from the medical situation causing stress (Demaso & Snell, 2013). Interestingly, this study also talks of maintaining routines to remind the child that they will eventually be back to their normal lives (Demaso & Snell, 2013). What the team seeks to do is find a way to counteract the common worries of children by using the knowledge of coping mechanisms along with the information learned from interviews to adjust the trajectory of Cub Companion to help pediatric cancer patients as best as possible.

Existing Products on the Market

It is already well-known both within and outside of the medical community that medical treatment can frequently cause stress and anxiety. Thus, many techniques exist for reducing the feelings of stress and anxiety during medical treatments, particularly for pediatric patients. The most commonly listed techniques include being educational, employing distractions, practicing calmness or breathing exercises, and providing physical comfort (Filion, 2015).

A few stuffed animal-style products exist for the purpose of education during medical procedures. One such product is Ben's Medibear, which employs "cuddly teddy bears as unique as their owners!" (Gallery | Ben's MediBearTM / MediBear, 2019). These customizable teddy bears can be made to sport scars, ports, and other medical devices or remnants from medical procedures to make the child feel less self-conscious as well as to educate the child (Gallery | Ben's MediBearTM / MediBear, 2019).

A similar product specific to feeding tube procedures is Tubie Friends, which uses various types of stuffed animals equipped with educational feeding tubes with the purpose of "taking the fear out of feeding tubes, one Tubie Friend at a time." (Tubie Friends :: Home, 2019).

Lastly, MediKins are designed to look like children and can be adapted with medical equipment or educational pictures of organs, the skeletal system, etc. (MediKinTM Teaching Aides | MediKins by Legacy Products, 2019). All three of these products aim mainly to educate the pediatric patient, but also serve as a method for providing physical comfort.

Existing products for employing distractions in medical treatment situations include Buzzy and DistrACTION cards (Buzzy Works for — Buzzy®, 2019; DistrACTION® Cards — Buzzy®, 2019). Buzzy is a small chilled and vibrating apparatus designed to look like a bumblebee, which boasts effectiveness in pain reduction by both numbing the area of injection and inhibiting effectiveness of local neurons with high frequency vibrations (Buzzy Works for — Buzzy®, 2019).

DistrACTION cards offer an interactive way for parents to distract their children while presenting a picture on one side of the card, and asking a shown age-appropriate question on the back of the card (DistrACTION® Cards — Buzzy®, 2019). Other commonly listed forms of distraction across many articles include squeezing stress balls, blowing bubbles, and spinning pinwheels.

"Kid Speak:" Using the Language of a Child

Existing products on the market aim mostly to distract or educate the child during treatment. For effective communication, one must understand how children speak. In the case of educating children during their treatment, a special linguistic strategy has to be implemented in order to convey the message without scaring the children. Communicating linguistically with a child is significantly different than doing the same with an adult. Due to the lack of maturity, a conversation with a child can easily be turned into an argument if not handled carefully (Faber & Mazlish, 1979). Linguistic and basic life skills are being acquired by children during their early childhood, which makes them naive at this stage of life. When an adult converses with a child, they must refine their use of language (Adger & Hoyle, 1998). Researchers working in this area call the use of this type of language 'child directed speech,' or CDS for short, which is commonly known in layman's terms as 'baby talk.' Common characteristics of CDS are a limited vocabulary, slower speech, a greater number of pauses, and grammatical simplification (Harley, 2010). Studies show that CDS is effective for both young children and infants for acquiring knowledge and cognitive skills development (Schachner & Hannon, 2011).

Children's Interactions with Products

In addition to knowing how to communicate effectively with children to aid in their education, it is necessary to understand how children may interact with educational or other products. While children's interaction with products is not the focus of the team's research, understanding how children will interact with Cub Companion can have a large influence on how parents and nursing personnel interact with the child through the mobile application. Children interact with an object differently than an adult does; for instance, children prefer instant outcome to their inputs and tend to take information literally (Molnár, 2018). Not only do children interact with objects differently than adults, they also interact with objects differently depending on the age of the child (Molnár, 2018). While the type of toy the child might prefer is dependent on the child's age, playing with any toy has been shown to be beneficial (Ghabeli, 2014). Children who have played with toy(s) before a procedure have been shown to have lower levels of anxiety when compared to those children who have not (Ghabeli, 2014). For Cub Companion, the child will be interacting directly with the object, and indirectly with the parent or medical personnel. This will allow the user of the mobile application to ensure Cub Companion is being used by the child in the most effective way. It is recommended for parents to be involved in the child's interaction with educational toys to ensure the child is getting beneficial educational information from the toy (Oravec, 2000).

USER NEEDS IDENTIFICATION

Based on work previously completed and interviews performed by the stakeholder, the goal of the team's user needs study was to gather as much information as possible from parents of pediatric cancer patients to assist in further framing of the problem described by the stakeholder. Additionally, the team sought to interview pediatric oncology nurses for their perspective of the children's reactions to stressors and the coping mechanisms presented during treatments and their effectiveness. Specifically, the team aimed to answer the following research questions (RQ):

RQ1: What level of understanding do parents and children have of pediatric cancer treatment procedures?

RQ2: What types of procedures throughout treatment cause the greatest amount of stress for the child?

RQ3: How do parents and medical personnel currently help pediatric cancer patients cope throughout treatment?

USER NEEDS METHODOLOGY

To answer these three research questions, an exploratory study was conducted with eight participants. Potential users of the Cub Companion product were interviewed by the team, including parents of children with cancer diagnoses and pediatric nurses. This section serves to summarize the methodological approach taken in this study.

Participants

Six parents of children who have gone through pediatric cancer treatment, one pediatric oncology nurse, and one nurse anesthetist were recruited for the preliminary user interviews. The parents interviewed were parents of children younger than ten years old throughout treatments. Three of the children were treated at Penn State Health Milton S. Hershey Medical Center ("Hershey") in Hershey, PA, and the other three were treated at Riley Hospital for Children at Indiana University Health ("Riley") in Indianapolis, IN. Similarly, the nurse anesthetist worked at Hershey and the pediatric oncology nurse worked at Riley.

After a participant agreed, the IRB protocol was followed. The formal IRB letter is shown in Appendix A. The demographics of the participants were as follows:

P1: Relationship to patient: Mother
Age of child during treatments: 5-8
Gender of child: Male
Diagnosis: Leukemia

P2: Relationship to patient: Mother
Age child started treatment: 2
Gender of child: Female
Diagnosis: Brain Cancer

P3: Relationship to patient: Father
Age of child during treatments: 5-8
Gender of child: Male
Diagnosis: Unknown

P4: Educational background: B.S. in Kinesiology and Integrated Physiology; B.S. in Nursing
Career background: About 2.5 years as a pediatric hematology/oncology inpatient nurse at Riley Children's Hospital.

P5: Relationship to patient: Mother
Age of child during treatments: 6-8
Gender of child: Male
Diagnosis: Leukemia

P6: Relationship to patient: Father
Age of child during treatment: 2-7
Gender of child: Male
Diagnosis: Leukemia

P7: Educational background: M.S. in Nursing
Career background: Critical care nurse for approximately 40 years, working with children and adults.

P8: Relationship to patient: Mother
Age of child during treatment: 5-8
Gender of child: Female
Diagnosis: Leukemia

Interview Procedure

All interviews were conducted via phone call. One team member prepared to take handwritten notes while the other prepared to make the phone call and start the recording device. All present team members introduced themselves, the goal of the study was reiterated and implied consent was obtained from the individuals as required through the IRB.

All interviews began with demographic questions. The process afterwards differed for which type of use was being interviewed. For parents, the team next led into questions relating to what kind of procedures were done, the parent's understanding of their child's procedures, and their child's understanding of the procedures. This was followed by questions to learn more about the biggest stressors throughout treatments. Knowing what the biggest stressors were led to questions regarding the emotions of the child leading up to and during treatment, common reactions to treatment, and the involvement of the parent during treatments. Finally, with the goal of determining effective coping methods, the parents were asked questions about coping methods from child life specialists, parents and family members, nurses, and any corresponding items that helped their child cope. The interview questions used for parents are shown in Appendix B.

Following demographic questions for medical personnel, the team led into a discussion of the most common treatments for children diagnosed with cancer, the levels of understanding of these procedures of both the children and the parents, how stressful each procedure is, and any effective coping methods presented by the medical personnel. The interview questions used for medical personnel are shown in Appendix C.

Qualitative Data Analysis

Each interview conducted was recorded using a mobile voice recording application on a Galaxy Tab A tablet. Interviewees were placed on speakerphone on the team member's cell phone with the tablet setup nearby to record. The output audio files were in mp3 format. The audio files underwent initial transcription with Amazon Transcribe by Amazon Web Services (Amazon Transcribe, n.d.). Audio transcriptions were then verified for accuracy by the researchers through listening to the audio recording and adjusting the transcription file as necessary. Any extraneous conversation or text that would not be analyzed was removed from the transcription files.

Due to general unavailability of prior research, an inductive approach was implemented for the qualitative content analysis. A preliminary code book, shown in Appendix D, was created based on observations from the team of major themes developed throughout the interviews. For ease of coding and having a better understanding of the analysis, the codes were subcategorized into seven categories, namely: comfort, distraction, breathing exercises, education, interaction, home-related, and involvement. The transcribed interviews were analyzed on NVIVO v.12 (QSR, 2012). Since eight interviews were conducted, the team used the 20 percent rule to check for inter-rater reliability. Using this rule, two interviews were analyzed separately by two team members and an inter-rater reliability test was conducted for each. The results for these inter-rater reliability tests are shown in Appendix E. As per the results obtained from the coding comparison query, the average kappa coefficient is found to be 0.7739. According to the Cohen's kappa scale, kappa values of 0.61-0.80 are considered good (Landis, 1977).

RESULTS

In pursuance of the research goals, the data of approximately 275 minutes obtained from the interviews were analyzed. The following subsection presents the detailed results obtained from interviews.

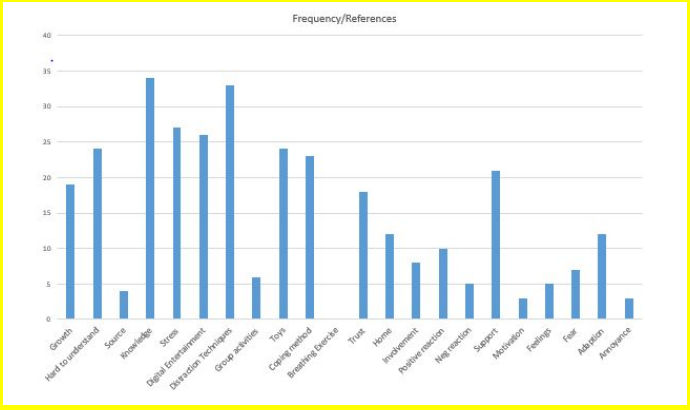


Fig 1: Frequency of the code in the data analysis versus code.

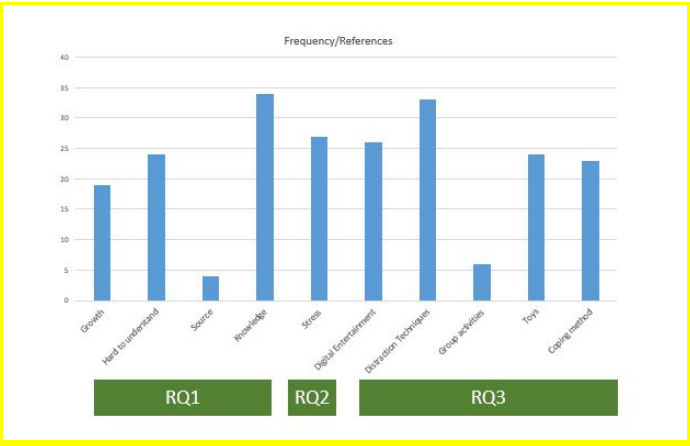


Fig 2: Frequency of code splitted as per research questions.

RQ1: What level of understanding do parents and children have of pediatric cancer treatment procedures?

According to the content analysis (Fig. 2), parents as well as children were not aware of the types of procedures and treatment in the initial stages. However, the growth code (f = 19) indicated that they eventually became familiar. The major sources of this information were pediatric nurses, parents of pediatric cancer patients, and child life specialists. During the interviews, the parents were specific about the treatment procedures received by their child, confirming their knowledge of the procedures. According to Participant 4, a pediatric oncology inpatient nurse, "I would say the whole process of understanding about the bone marrows is like really difficult to

wrap your head around, especially if you like don't have medical background, let alone any education. But I think that our parents understand to the point that they need to understand." It was also hinted by nurses that children are smarter than they seem.

RQ2: What types of procedures throughout treatment cause the greatest amount of stress for the child?

There was no specific type of procedure which could be attributed to causing the greatest amount of stress. Mostly, the stress for the child was due to the sudden change in lifestyle during the early stages of treatment. Some of the parents indicated that they were having difficulties with the process of seeing their children undergo these medical procedures. However, during the later stages of treatment, the child adopted the new lifestyle, thus resulting in a decrease of stress (f = 12, Fig. 1). The children learned to trust their parents and nurses (f=18, Fig. 1) which led to lower stress during procedures.

Speaking of his child, Participant 6 said, "when we used to get the lumbar punctures, that makes you pretty loopy. Actually, uh, it's kind of like an anesthesia while you're kind of awake. But when that part of the visit always came up, he said, 'when am I going to get my happy medicine,' which occurred when they would do a lumbar puncture, which was always stressful." As per the interviews, it seemed that the most stressful time for a child was during the early stages of treatment, right before the procedures. The new environment, combined with fear of the unknown and anticipation of the procedure, induced a great amount of stress to the child. Additionally, for the most painful procedures, the child would receive general anesthesia. During the later stages of treatment, the procedures became routine and the stress associated with them plummeted.

RQ3: How do parents and medical personnel currently help pediatric cancer patients cope throughout treatment?

According to the interviewees, by far the most common coping technique for treatment of pediatric cancer patients was distraction during difficult procedures. Interpreting from the data, the most common way of distracting a child is the use of digital entertainment (f = 26), such as with an iPad, television, cartoons, and even music therapy. Other distraction techniques such as arts and crafts, group activities, and use of toys were also mentioned. None of the interviews hinted at breathing exercises being used as a coping method during treatment (f=0).

According to Participant 6, "you might have to hold [him] down or completely distract him by doing something fun or something to draw or color or watch it on television or on a tablet. They keep their minds off what's going on." This quote indicates that to be effective, the distraction method should be fun and immersive for the child.

PROTOTYPE DEVELOPMENT

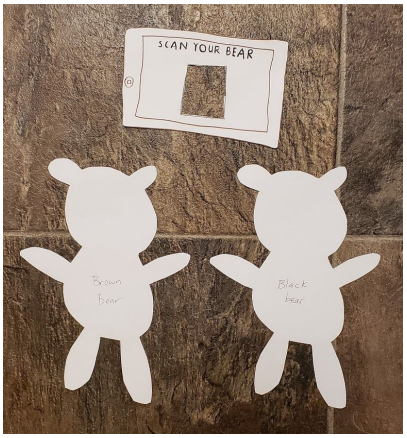
Based on the results of the content analysis of qualitative data gathered from user interviews, the team was able to develop a concept for a prototype. The initial idea for Cub Companion included two aspects - a physical stuffed bear and a corresponding mobile application. Cub Companion's original intent was to encompass comfort, breathing exercises, distraction techniques, and education of treatment procedures. During interviews, it became evident to the team that breathing exercises and education were not important features as identified by users. It was also concluded that comfort is provided primarily by the presence of the parents and secondarily with an item such as a stuffed animal or a blanket. Themes of building trust with medical personnel and providing distraction were mentioned by almost all interviewees, and became the focus for prototyping.

In an effort to build trust with the nursing staff and provide distraction from the new environment and medical procedures, the team decided that the mobile application should be designed as a virtual world. A patient-created customizable teddy bear may be uploaded into the virtual world, and a virtual representation of the real-life nurses interact with the bear to help guide it through the world and assist with different games available to the user.

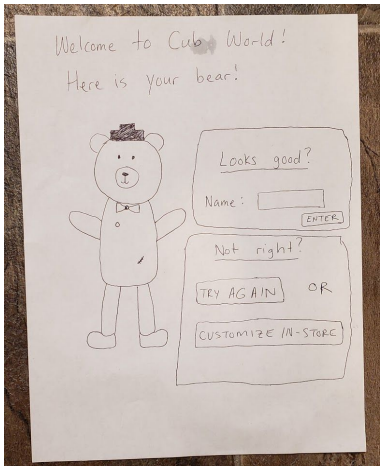
The prototyping process began with a low-fidelity paper prototype of the virtual world. This paper prototype was tested with users from the university course, and the feedback was used to create a medium-fidelity prototype. This second version of the prototype included both a physical teddy bear and a mobile application simulation in Adobe XD. The medium-fidelity prototype will be tested with users from Penn State outside of the university course. During user testing, both quantitative and qualitative data was gathered and analyzed. The conclusions drawn from the data aided the team's suggestions for the stakeholder.

LOW-FIDELITY PROTOTYPE

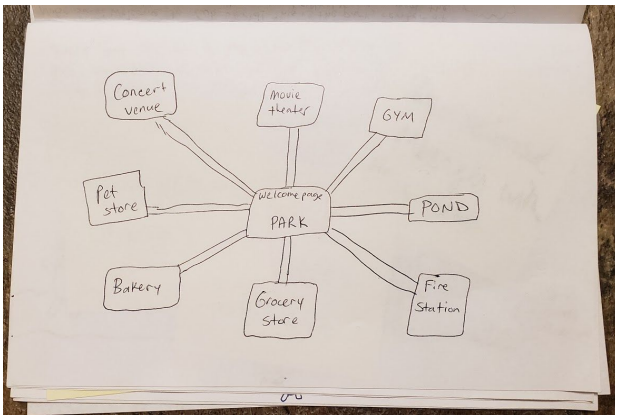
An initial low-fidelity paper prototype was created based on the feedback from the user interviews. Its aim was to provide as much distraction as possible to the patient through virtual areas, games, and interaction with other users. The paper prototype was in the style of a flip-book, and showed various parts of the virtual world. The paper prototype was divided into three parts - customizing the paper bear, taking a picture of the bear to input into the virtual world, and the virtual world. Customizing the bear simulated the physical component of the product, and the user could choose from two different paper bears and customize it using either medical accessories like stitches and access ports or non-medical accessories like hats and shoes. After completing the bear, the next step was to take a picture and upload it into the virtual world. This was simulated using a paper representation of an iPad modeled as a simple camera application interaction. The picture on the next page shows the paper bears and the paper iPad.



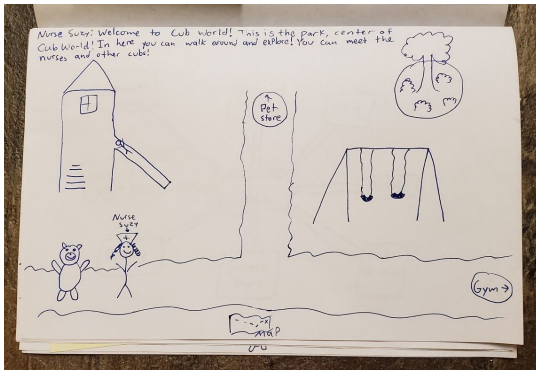
Once "uploaded" to the virtual world, the bear is animated and will be able to navigate through the mobile application. The first page of the mobile application paper prototype was the picture of the bear, as shown in the photo below. The user then had the option to name their bear, or re-scan the bear if the animated version did not match the inputted picture.



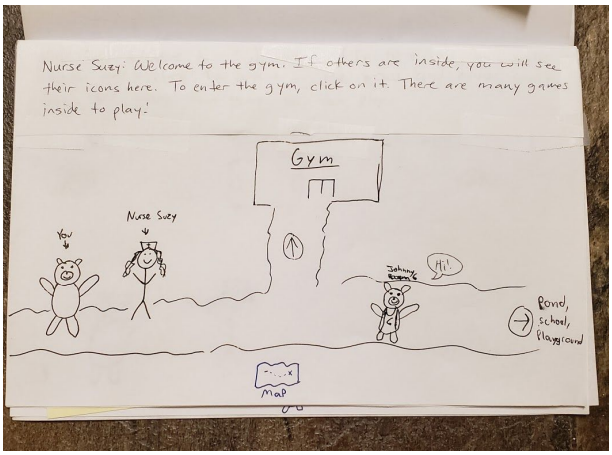
Once the inputted bear was considered correct, the next page the user was brought to was a home screen where the bear will meet the nurse. The nurse introduces the main area of Cub World. This main page is shown in the picture below.



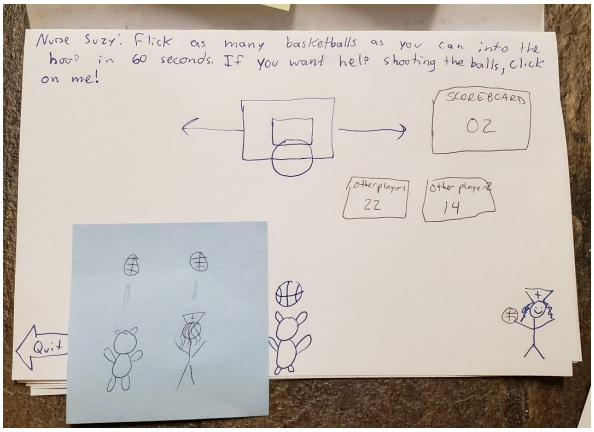
The bear has access to various other spots in the virtual world via a map or sequential paths that navigate from area to area. The sequential paths are highlighted in the previous picture, and the map of all available areas is shown in the picture below.



For testing the paper prototype, the team focused on having users complete one activity within the virtual world. The user was told to go to the gym and play basketball. The part of the world that the gym is located in is shown below.



Once the gym was entered, several games were available to play, including basketball. A picture of the inside of the gym is shown below. The user may either play by themself, or may click on the nurse to receive help (shown in the purple sticky note).



During testing, the team measured the time it took the user to complete the task, the number of errors made by the user, and which method was used to arrive at the game page (either sequential paths or the map).

Although versions of the parental aspect of the mobile application were prototyped on paper, they were not tested with the users. The parental control interface allowed a parent login page for security purposes as well as allowing the parent to create a virtual nurse profile. A virtual nurse may be created by capturing a photo and customizing the figure, similarly to the way the bear is put into the virtual world.

The paper prototype was presented to two other classmates and the stakeholder for feedback. The test users were given the task of building a bear with a hat, bowtie, shoes, access port, and stitches. The colors of each were specified to the user. Next, the user was asked to take a picture of their bear using the paper iPad and run through the virtual world from the bear upload page to playing the basketball game.

The test users liked the idea of having a customized bear in the virtual world. They were also intrigued by the idea of having a nurse assistant in the virtual world which can help in building trust between the child patient and the real-life nurse. The idea of having a more interactive nurse was discussed during the meeting with the stakeholder. Much user feedback was given on where to place certain aspects of the virtual world, as well as interacting with the nurse through speech bubbles instead of text at the top of the screen. In addition, it was decided that a better way to get to know the nurse was to have a part of the virtual world dedicated to each nurse profile, with games specific to the interests of the real-life nurses. Thus, the main goal of the second prototype was to focus more on interaction with the nurse to build trust with the patient, as well as optimization of feature size, placement, and text usage.

MEDIUM-FIDELITY PROTOTYPE

Since the university course this project is attached to is focused on interaction design, the team was asked to focus on the interaction between the user, the physical stuffed bear, and the mobile application. Therefore, the medium-fidelity prototype had both a physical bear component and a mobile application component.

After receiving feedback from the low-fidelity prototype, it was clear that the focus needed to be shifted toward specific interactions between the child and the virtual nurse. This led to reshaping how the virtual and physical components were approached. The physical component includes the base stuffed bear along with a variety of aesthetic or medical accessories from which the the participants may choose. The virtual component was designed to have three main functions:

1) Parental step of signing on, scanning the custom bear into the virtual world, and selecting a nurse before the child begins,
2) Allowing the child to click around the world of the virtual nurse to learn more about them in real-life, and
3) Playing a game in which the nurse gives affirming messages and plays against the child.

Making the Bear (shown below)

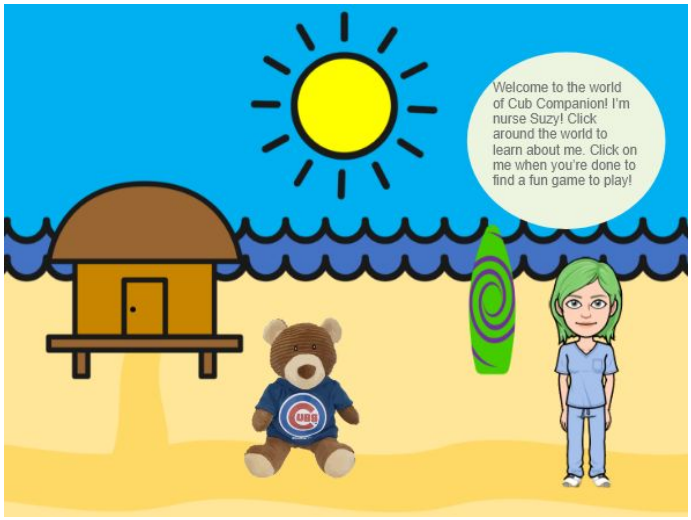
The first step within the medium-fidelity prototype is the customization of the physical stuffed bear. Participants are presented with a basic undecorated stuffed bear. After that, participants are able to choose a variety of medical and non-medical accessories to customize the bear. The non-medical accessories include shirts, hats, ties, glasses, and wristwatches, while stitches, IVs, and access ports represent medical devices that the participants can add to the bear. The hope of this portion of the prototype is to spark a sense of control and companionship in the child by making a customized bear they like.

Scanning the Bear (shown below)

This portion is aimed toward the parents of the children. Parents enter the application by pressing a button to scan the bear, and are then prompted with a camera screen. Once satisfied with the virtual representation of the bear, they can

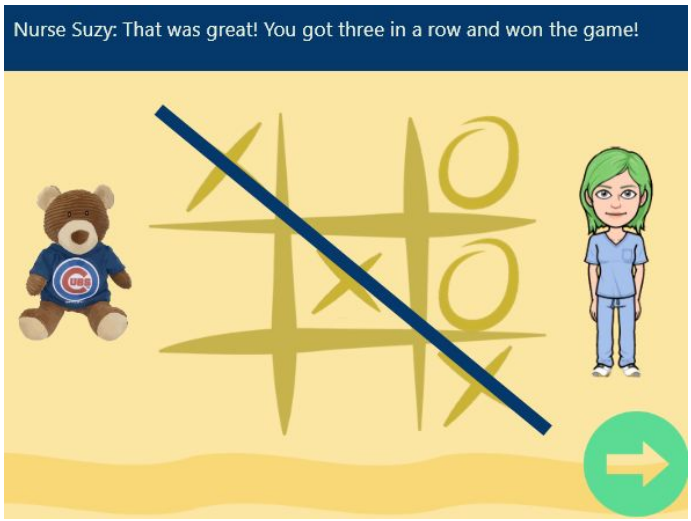
move on to selecting the child's nurse before handing off the game to the child.

Initial Exploration (shown below)



The beginning of the game presents the user with a world including their virtual bear and the selected nurse. There is a welcome message followed by prompts to click around and learn more about the nurse. This is where the user can click on various objects and a message from the nurse will appear to tell the user more about them, correlating to the interests of the real-life nurse. The user can also click on the nurse directly to be taken to a similar screen with the option to begin a game of tic-tac-toe.

Playing the Game (shown below)



As a medium fidelity prototype, the tic-tac-toe game was simply a simulation. The game is preset to follow specific placements regardless of where the user taps to simulate a game against the nurse. After each move, the nurse will give an affirming message until a timer moves to the next screen to simulate the nurse's next move. The game is set to model the child winning the game and the nurse being supportive and congratulating.

PROTOTYPE TESTING

The purpose of the prototype study was to test if the interaction design created fosters a greater sense of trust in the nurse. It is also important that the prototype distracts the user from outside thoughts while using it. Specifically, the team aimed to answer the following research questions (RQ):

RQN+1: Does trust in the nurse increase when she is interactive versus passive?

RQN+2: Does the virtual world provide adequate distraction from the outside world?

RQN+3: Is the mobile application efficient, effective, and satisfactory to users as designed?

METHODOLOGY

The prototype was created in order to answer the three research questions listed above. The first phase of testing was to customize the stuffed bear. During this phase, the participant had the option to choose aesthetic and/or medical items to customize the bear. The number of aesthetic items and the number of medical items the participant chose were monitored during this phase. The next phase of testing was to simulate scanning the bear into the mobile application. During this phase, time to complete the runthrough and the number of errors made by the participant will be tracked. The next phase of the prototype was used to evaluate the level of trust in the nurse. To analyze this, the team used a mixed study approach to testing. Participants ran through the same scenario twice, once with a interactive nurse, and once with a passive nurse. In an attempt to prevent an ordering effect, the order of which nurse is shown first was randomly assigned to the participants. To prevent biases from different backgrounds, the nurses' appearances were made as neutral as possible and non-natural hair colors were used. To account for each combination of differences, a total of eight scenarios were generated and randomly assigned to the participants, with scenarios repeated in groups of eight (Fig. 3). After the prototype testing was complete, participants were asked to take a survey. This survey was used to gather qualitative data such as how well the participant felt they knew the nurse, how much the participant trusted the nurse, how helpful the participant found the nurse to be, the participant's satisfaction with customizing the bear, and the overall satisfaction with the mobile application.

Scenario	Good Nurse	Nurse Hair	Bad Nurse	Good Environment	Bad Environment
1	Suzy	Green	Jen	Beach	Woods
2	Suzy	Green	Jen	Woods	Beach
3	Jen	Pink	Suzy	Beach	Woods
4	Jen	Pink	Suzy	Woods	Beach
Scenario	Bad Nurse	Nurse Hair	Good Nurse	Bad Environment	Good Environment
5	Suzy	Green	Jen	Beach	Woods
6	Suzy	Green	Jen	Woods	Beach
7	Jen	Pink	Suzy	Beach	Woods
8	Jen	Pink	Suzy	Woods	Beach

Fig. 3: Experimental matrix for prototype testing simulations.

Participants

Participants for prototype testing were recruited in-person from the Biobehavioral Health (BBH) and Health and Human Development (HHD) buildings on the campus of Penn State University. These participants were chosen due to their studies being focused on behavioral health science and psychology. In total, 16 participants performed prototype testing, two for each of the scenarios (Fig. 3). These participants were between the age range of 18-27 years, with a median age of 21 years.

Prototype Testing Procedure

Each participant was asked to read and sign the IRB form, and informed that audio recording and screen capturing were to be used in this study. The participants were then given the $15 compensation. Before prototype testing was started, audio recording was initiated using the Voice Recorder application on a Google Pixel 3 XL cell phone. First, participants completed the demographic information portion of the survey, which is shown in Appendix F. Next, the participants were asked to complete the physical portion of the prototype by customizing the stuffed bear. After completing this task, participants were instructed to complete the virtual portion of the prototype using a 5th generation Apple iPad to engage with the mobile application. This mobile application prototype was created using Adobe XD. Screen recording was initiated before the virtual portion of testing through the built-in Screen Recording Application on the iPad. Once participants completed the virtual portion of testing, they were instructed to complete the remainder of the survey (Appendix F), which completed the prototype testing.

DATA ANALYSIS AND RESULTS

This usability study utilizes a mixed design approach to answer the developed research questions. The qualitative and quantitative data collected is shown in Appendix G. In addition to the research questions, the ordering effect of which nurse environment was prevented first needs to be explored further. The mixed design consists of the three factors listed below:

1) Type of nurse (within factor): Interactive (Good) or Passive (Bad)
2) Order of the nurse environments presented (between factor): Good-Bad or Bad-Good
3) Environment of the virtual world (between factor): Beach-Woods or Woods-Beach

The results of the study are divided by research question in the next sections.

RQN+1: Does trust in the nurse increase when she is interactive versus passive?

Trust in the nurse was assessed by collecting Likert-type data in the form of a survey. A total of six questions were asked at the end of prototype testing, including one direct question about trust and two indirect questions each about helpfulness of the nurse (Helpfulness Score) and the level of familiarity with nurse's background (Know Score). Since there are no non-parametric tests available for mixed design, a parametric test was used to measure the group differences per the paper published by Norman in 2010 (Norman, 2010). A three-way ANOVA is found to be most suitable statistical test for analysing the group differences using Laerd Statistics (Laerd Statistics, 2018).

Trust Score

A three-way mixed ANOVA was run to understand the effects of type of nurse, ordering effect, and environment type on perceived trust for the task of playing tic-tac-toe. Trust scores were not normally distributed, as assessed by Shapiro-Wilk's test ($p < 0.05$). There were no outliers in the data, as assessed by inspection of a boxplot. There was homogeneity of variances, as assessed by Levene's test for equality of variances ($p > 0.05$).

There was no statistically significant three-way interaction between type of nurse, order of nurses presented, and environment of virtual world $F(1, 12) = 0.453$, $p = .0514$, partial $\eta^2 = 0.036$. There was no statistically significant simple two-way interaction between type of nurse and order, $F(1, 12) = 1.811$, $p = 0.203$ and with environment, $F(1, 12) = 1.019$, $p = 0.333$. There was no statistically significant simple main effect of type of nurse used, $F(1, 12) = 2.830$, $p = 0.118$, order in which the nurse were presented, $F(1, 12) = 4.596$, $p = 0.053$ and the environment of virtual world, $F(1, 12) = .128$, $p = 0.727$.

Helpfulness Score

A three-way mixed ANOVA was run to understand the effects of type of nurse, ordering effect, and environment type on perceived helpfulness of the nurse for the task of playing tic-tac-toe. Trust scores were not normally distributed, as assessed by Shapiro-Wilk's test ($p < 0.05$). There were no outliers in the data, as assessed by inspection of a boxplot. There was homogeneity of variances, as assessed by Levene's test for equality of variances ($p > 0.05$). There was no statistically significant three-way interaction between type of nurse, order of nurses presented, and environment of virtual world $F(1, 12) = 0.273$, $p = 0.611$, partial $\eta^2 = 0.022$. There was no statistically significant simple two-way interaction between type of nurse and order, $F(1, 12) = 2.455$, $p = 0.143$ and with environment, $F(1, 12) = 2.455$, $p = 0.143$. There was a statistically significant simple simple main effect of type of nurse used, $F(1, 12) = 13.364$, $p = 0.003$, but not of the order in which the nurse were presented, $F(1, 12) = 4.357$, $p = 0.059$ and the environment of virtual world, $F(1, 12) = 0.739$, $p = 0.407$.

Familiarity Score

A three-way mixed ANOVA was run to understand the effects of type of nurse, ordering effect, and environment type on learning about the nurse for the task of playing tic-tac-toe. Trust scores were not normally distributed, as assessed by Shapiro-Wilk's test ($p < 0.05$). There were no outliers in the data, as assessed by inspection of a boxplot. There was homogeneity of variances, as assessed by Levene's test for equality of variances ($p > 0.05$). There was no statistically significant three-way interaction between type of nurse, order of nurses presented and environment of virtual world $F(1, 12) = 0.284$, $p = 0.604$, partial $\eta^2 = 0.023$. There was no statistically significant simple two-way interaction between type of nurse and order, $F(1, 12) = 0.032$, $p = 0.862$ and with environment, $F(1, 12) = 1.547$, $p = 0.237$. There was a statistically significant simple simple main effect of type of nurse used, $F(1, 12) = 13.926$, $p = 0.003$, but not of the order in which the nurse were presented, $F(1, 12) = 0.701$, $p = 0.419$ and the environment of virtual world, $F(1, 12) = 0.701$, $p = 0.419$.

RQN+2: Does the virtual world provide adequate distraction from the outside world?

In order to assess the level of distraction from the outside world, a question was asked in the post-testing survey and Likert-type data was collected. A median immersion score ($M = 4$) was higher than the standard neutral immersion score of 3.0, indicating that distraction was significant.

RQN+3: Is the mobile application efficient, effective, and satisfactory to users as designed?

As mentioned earlier, the mobile application was designed in two sections: the parent section and the virtual world. In order to assess the efficiency and effectiveness of the parent section, time to complete the task of navigation through the parent section and number of error clicks were recorded.

Parent Section

The mean time to complete the parent section of the mobile application ($M = 17.4$) was higher than the expert's time to complete ($T = 10$). The mean number of errors while completing the parent section of the app ($M = 0.4$) was higher than the expert's number of errors (# of errors = 0).

Virtual World

In order to evaluate the effect of factors on the efficiency of the mobile application, the time to complete the task of playing tic-tac-toe is recorded.

Time to Complete

A three-way mixed ANOVA was run to understand the effects of type of nurse, ordering effect, and environment type on time to complete the task of playing tic-tac-toe. Time scores were normally distributed, as assessed by Shapiro-Wilk's test ($p > 0.05$). There were no outliers in the data, as assessed by inspection of a boxplot. There was homogeneity of variances, as assessed by Levene's test for equality of variances ($p > 0.05$). There was no statistically significant three-way interaction between type of nurse, order of nurses, and environment of virtual world $F(1, 12) = 0.293$, $p = 0.598$, partial $\eta^2 = 0.024$. There was a statistically significant simple two-way interaction between type of nurse and order, $F(1, 12) = 21.640$, $p = 0.001$, but not with environment, $F(1, 12) = 0.469$, $p = 0.506$. There was a statistically significant simple simple main effect of type of nurse used, $F(1, 12) = 42.602$, $p < 0.001$, order in which the nurse were presented, $F(1, 12) = 14.416$, p 0< .001, but not the environment of virtual world, $F(1, 12) = 1.414$, $p = 0.257$.

Number of Clicks

The number of clicks and errors is recorded to evaluate the effectiveness of the virtual world. A three-way mixed ANOVA was run to understand the effects of type of nurse, ordering effect, and environment type on number of clicks for the task of playing tic-tac-toe. The number of clicks were not normally distributed, as assessed by Shapiro-Wilk's test ($p < 0.05$). There were no outliers in the data, as assessed by inspection of a boxplot. There was homogeneity of variances, as assessed by Levene's test for equality of variances ($p > 0.05$). There was no statistically significant three-way interaction between type of nurse, order of nurses presented and environment of virtual world $F(1, 12) = 0.466$, $p = 0.508$, partial $\eta^2 = 0.037$. There was a statistically significant simple two-way interaction between type of nurse and order, $F(1, 12) = 5.385$, $p = 0.039$, but not for environment, $F(1, 12) = 0.168$, $p = 0.689$. There was a statistically significant simple simple main effect of type of nurse used, $F(1, 12) = 48.466$, $p < 0.001$, order in which the nurse were presented, $F(1, 12) = 6.898$, $p = 0.022$, but not the environment of virtual world, $F(1, 12) = 0.478$, $p = 0.503$.

Number of Errors

A three-way mixed ANOVA was run to understand the effects of type of nurse, ordering effect, and environment type on number of errors for the task of playing tic-tac-toe. The number of errors were not normally distributed, as assessed by Shapiro-Wilk's test ($p < .05$). There were no outliers in the data, as assessed by inspection of a boxplot. There was homogeneity of variances, as assessed by Levene's test for equality of variances ($p > 0.05$). There was no statistically significant three-way interaction between type of nurse, order of nurses presented and environment of virtual world $F(1, 12) = 0.532$, $p = 0.480$, partial $\eta^2 = 0.042$.

There was no statistically significant simple two-way interaction between type of nurse and order, $F(1, 12) = 0.021$, $p = 0.886$, and with environment, $F(1, 12) = 0.021$, $p = 0.886$. There was a statistically significant simple simple main effect of type of nurse used, $F(1, 12) = 19.041$, $p = 0.001$, but not the order in which the nurse were presented, $F(1, 12) = 4.492$, $p = 0.056$ and the environment of virtual world, $F(1, 12) = 0.762$, $p = 0.400$.

Satisfaction

Satisfaction of customizing the bear and the entire application is assessed through the Likert-type data collected by survey questions. The median mobile application satisfaction

score (M = 4) was higher than the normal neutral mobile application satisfaction score of 3.0. The median bear satisfaction score (M = 4.5) was higher than the normal neutral bear satisfaction score of 3.0.

DISCUSSION

The usability study demonstrated the ability of the prototype to help in building trust between the user and the nurse and to provide distraction from the outside world. Users found the mobile application to be immersive and provide adequate distraction from the outside world. The interactive nurse was found to be more trustworthy as per statistically significant group differences of the helpfulness score and familiarity score. However, due to the ordering effect, the trust score was not found to be statistically significant. Users took more time to navigate to the task of playing the tic-tac-toe game with the interactive nurse since there were additional features and a greater number of clicks. However, users who were presented the passive nurse first usually skipped the additional features of the interactive nurse, thus affecting the analysis of completion time. The interactive nurse environment was found to induce more errors in clicking. In general, the users found that customizing the bear and using the mobile application were satisfying.

DESIGN RECOMMENDATIONS

Before the team joined this project, the stakeholder interviewed with child life specialists to gain an idea of the best focus for Cub Companion. Due to the introduction of child life specialists and technology, it seemed that in-hospital treatment is now pretty well-managed. Thus, the stakeholder asked the team to focus the user interviews on home care, when child life specialists and nurses are not available. Upon consideration of the main themes generated by the user interviews, the team decided there should be a shift in focus for the Cub Companion project. The team found that the vast majority of procedures are performed in the hospital, and any particularly difficult treatments done at home will have a nurse present. The team then re-focused on hospital procedures, using the main themes of building trust with the medical personnel and distraction from invasive treatments that emerged from the user interviews.

As with all pediatric patients, comfort remains an important aspect in reducing the anxiety associated with medical procedures. This, along with the themes that emerged from the user interviews, was kept in mind when the team developed a prototype. The prototype maintained the original concept of having a physical component and a virtual component to Cub Companion. A customizable stuffed bear will allow the child to create a positive memory from the cancer diagnosis by creating a buddy that can emulate their medical equipment and personal style to comfort them throughout treatment. This customized bear may then be imported into a virtual world via a mobile application, which allows the child to play games with virtual nurses to provide distraction during invasive procedures and allow trust to be built with the real-life nurses. The first paper prototype focused on what games might be provided, and the feedback indicated that the interaction with nurses to build trust should be the focus of the second prototype. The finished medium-fidelity prototype simulated playing a game with a virtual nurse, whose interests were based on the real-life nurse and reflected in the interactive virtual environment. In both versions, the participants simulating playing a game of tic-tac-toe with the nurse. The interactive nurse had an additional feature of a clickable environment, where different information about the real-life nurse's interests was available by clicking on parts of the environment.

The prototype's ability to build trust with the nurse, provide distraction, and general effectiveness were tested. Two versions of the prototype were tested - one with an interactive, helpful nurse, and one with a more passive nurse. Based on the testing performed, there was no significant difference in trust built with the interactive nurse over the passive nurse. However, a significant ordering effect was found, which leads the team to believe that the results were confounded by participants learning that they do not need to interact with the nurse to accomplish the task of playing the game. If the participant was presented with the passive nurse first, the team noticed they were less likely to attempt to learn about the interactive nurse. However, the participants generally seemed to like the ability to play with the nurses in the virtual world. Additionally, the jimmersion score was higher than a neutral average, which indicates that the game provides significant distraction to the user.

For future work, the team suggests performing more testing of the interactive nurse to assess trust when compared to a neutral average. Testing may be further developed to avoid an ordering effect, but it seems that having a virtual nurse present at all is the main factor in building trust with the real-life nurses. Additionally, it may be beneficial to perform more research and prototype testing to analyze which types of games are most beneficial for distracting children and providing adequate interaction with the virtual nurse.

CONCLUSION

Early interviews conducted with child life specialists led to the initial four pillars of Cub Companion being comfort, education, distraction techniques, and breathing exercises. However, user interviews with parents of pediatric cancer patients and pediatric nurses shifted the focus of Cub Companion to building trust with medical personnel and providing distraction during medical procedures. Based on this evidence, prototypes were created to combine a customizable physical stuffed bear with a virtual world providing games that can be played with nurses modeled after the real-life medical personnel. After preliminary user testing of a medium-fidelity prototype, the virtual world shows promise for being capable of providing distraction and helping the child build trust with medical personnel.

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Appendix A

Formal Request for Participation in Research Study

Dear (participant name),

My name is (sender's name), and I am currently involved in a research study in the School of Engineering Design at Penn State University.

You are invited to participate in this research study which seeks to understand the stresses involved in treatment for pediatric cancer patients and how parents and caregivers interact with these patients. The information that we gain from this study will help us understand effective coping methods during cancer treatments to mitigate negative short- and long-term, physical and psychological effects.

If you choose to participate in this study, you will take part in an interview lasting no more than 60 minutes. This interview can be done in person or over a video/audio call. In the interview, we will ask you questions regarding your experiences with childhood cancer treatment. Participants will receive $10 for participating in the interview.

The researcher in oversight of this study is Prof. Scarlett Miller from the School of Engineering Design at Penn State University. Please address any questions that you have about this study to Prof. Scarlett Miller at 814-863-4143.

If you wish to participate in the study, please respond to this email with your contact details, preferred method of communication, and soonest availabilities.

Thank you,
(Name)
Cub Companion Team
Pennsylvania State University

Appendix B

Interview Questions for Parents

Legal disclaimer:

This research study seeks to understand the stresses involved in treatment for pediatric cancer patients and how parents and caregivers interact with them. By participating in this interview you are giving us your consent to use your answers for this study. Do you have any issues with us recording this interview? By participating in this interview, you are eligible to receive $10. If desired, the team will mail you a form to sign, and upon receipt of the signed form, will mail you $10.

1. Demographics/Background
    a. Participant number
    b. Relationship to patient
    c. Age of patient during diagnosis and treatments

RQ1: What level of understanding do parents and children have of pediatric cancer treatment procedures?

2. What procedures has your child received?
    a. What procedures/treatments are performed at home?
3. How well do you understand the procedures?
    a. What's hard for you to understand?
4. How well does your child understand the procedures?
    a. What's hard for them to understand?
5. What do you want the child to know about the procedures?
    a. (immediate effects, later effects, purpose of treatment)
6. What procedures are the hardest for the child to understand?

RQ2: What types of procedures throughout treatment cause the greatest amount of stress for the child?

7. Can you walk us through a day when you take your child to the hospital for treatment?
    a. Is this a typical day of treatment?
        i. What is a typical day?
    b. Did you bring anything with you?
        i. What did you bring?
8. What feelings does your child have towards their treatment?
9. Does your child find treatment to be stressful? If so how?
10. How does your child feel knowing they are about to go into treatment?
11. What parts of your child's treatment are you involved in?
12. Would you like to be more involved? If so, how?
13. When you are in the hospital for treatment, who is typically in the room with you and your child?
    a. Are there ever child life specialists?
        i. How often?
        ii. How do they interact with your child?
        iii. Do they provide them with any specific coping mechanisms?
            1. How does your child react to these coping mechanisms?
    b. Nursing staff
        i. How do they interact with your child?
        ii. Do they provide coping mechanisms?
            1. How does your child react to these coping mechanisms?

c. You
    i. How do you interact with your child?
    ii. Do you provide coping mechanisms?
        1. How does your child react to these coping mechanisms?

14. Can you walk us through a typical at home treatment?
15. Do you have any additional help for at-home treatment?
    a. Family members, friends, etc
    b. How do they help?
16. Do you feel more involved in your child's treatment while at home?

RQ3: How do parents and medical personnel currently help pediatric cancer patients cope throughout treatment?

17. After/during treatments, were child life specialists present to help your child cope?
    a. How did you handle helping your child without child life specialist available?
18. What current coping methods do you see help your child?
    a. (distraction, breathing, comfort, education)
    b. What kinds of distraction techniques have you tried with your child?
    c. What comforts your child?
19. Have you given your child a toy/teddy bear during treatment?
    a. How did this affect the child?

Wrap-up

20. Is there anything else you think is important for us to know, or something you'd like to see researched in this area?
21. Do you know anyone else who would be interested in participating in this interview?

Appendix C

Interview Questions for Medical Personnel

Legal disclaimer:

This research study seeks to understand the stresses involved in treatment for pediatric cancer patients and how parents and caregivers interact with them. By participating in this interview you are giving us your consent to use your answers for this study. Do you have any issues with us recording this interview? By participating in this interview, you are eligible to receive $10. If desired, the team will mail you a form to sign, and upon receipt of the signed form, will mail you $10.

1. Demographics/Background
    a. Assign participant number
    b. Educational background
    c. Career background
2. What are the most common treatments for children with cancer diagnoses?
3. How often are each of the procedures repeated?
4. How well do the parents understand the procedures?
    a. Do you explain to the parent what is being done and why?
    b. How do you explain?
    c. How well do they understand?
    d. What are the hardest procedures for them to understand?
5. How well do the parents understand the procedures?
    a. Do you explain to the parent what is being done and why?
    b. How do you explain?
    c. How well do they understand?
    d. What are the hardest procedures for them to understand?
6. What treatments do you see the children struggle with the most?
7. What coping methods do you see help the children?
8. Are children ever presented with a toy during treatment?
    a. What kinds of toys?
    b. How do they react?
9. What are typical sterilization procedures for toys and where children can take them?

Wrap-up

10. Is there anything else you think is important for us to know, or something you'd like to see researched in this area?
11. Do you know anyone else who would be interested in participating in this interview?

Appendix D

Code Book Developed for Content Analysis

Code Book

Categories	Codes	Description
Comfort	Stress	Event that are more stressful
	Support	Event indicating the need of support by someone or something
	Coping Method	Coping methods
	Adaptation	Adapted to the new life
	Feelings	Kind of feelings induced during a particular event
	Fear	Fear from Pills, syringe or any other medical instrument or procedure
	Motivation	Needed motivation for survival
	Annoyance	Gets annoyed due to some event
	Trust	Nurses and child life specialists reassuring the parents and the children
Distraction	Toys	Use of toys for distraction or comforting,blanket, any physical instrument
	Techniques	Any other distraction technique
	Digital Entertainment	Watching TV, movies ,cartoons, Music therapy,games
	Group Activities	Ronald Mcdonald Cart, Bingo
Education	Growth	No understanding of procedures/treatments at beginning of diagnosis but second nature by the end of it.
	Level of Knowledge	Indicates the level of knowledge that she or he had
	Source	What was the source of knowledge ?
	Hard to understand	What things were very difficult for a child or parent to understand during the treatment ?
Breathing Exercise	Breathing exercise	
Interaction	Positive Reaction	Positive response to the coping method
	Negative Reaction	Negative response to the coping method
Home Related	Home specific	Specific home related procedures, distraction techniques
Involvement	Involvement	Showing the involvement of particular person in the treatment process

APPENDIX E

INTER-RATER RELIABILITY STUDY: COHEN'S KAPPA

Code	File	File Folder	File Size	Kappa	greement (%)	A and B (%)	Not A and Not B (%)	sagreement (%)	A and Not B (%)	B and Not A (%)	EF	TA	TU
Adaption	Parent_3	Files	28877 chars	0.6948	96.21	4.73	91.49	3.79	0.48	3.3	87.60	96.21	100.00
Annoyance	Parent_3	Files	28877 chars	1	100	0	100	0	0	0	100.00	100.00	100.00
Coping Metho	Parent_3	Files	28877 chars	0.7602	94.37	10.76	83.61	5.63	1.66	3.98	76.52	94.37	100.00
Digital Enterta	Parent_3	Files	28877 chars	0.845	97.69	6.93	90.77	2.31	2.31	0	85.13	97.69	100.00
Distraction Te	Parent_3	Files	28877 chars	0.8755	98.06	7.56	90.5	1.94	0.4	1.54	84.39	98.06	100.00
Feelings	Parent_3	Files	28877 chars	0.5017	98.78	0.62	98.16	1.22	0	1.22	97.56	98.78	100.00
Group Activiti	Parent_3	Files	28877 chars	0.8696	98.77	4.33	94.45	1.23	0.97	0.26	90.62	98.77	100.00
Growth	Parent_3	Files	28877 chars	0.6594	92.26	9.13	83.13	7.74	1.56	6.18	77.27	92.26	100.00
Hard to under	Parent_3	Files	28877 chars	0.8152	97.02	7.35	89.67	2.98	1.55	1.43	83.88	97.02	100.00
Home	Parent_3	Files	28877 chars	0.7318	96.78	4.78	91.99	3.22	0.02	3.21	87.98	96.78	100.00
Involvment	Parent_3	Files	28877 chars	0.9976	99.99	2.97	97.01	0.01	0.01	0	94.21	99.99	100.00
Knowledge	Parent_3	Files	28877 chars	0.7122	93.71	9.34	84.38	6.29	3.6	2.69	78.16	93.71	100.00
Motivation	Parent_3	Files	28877 chars	0	99.72	0	99.72	0.28	0	0.28	99.72	99.72	100.00
Negative Rea	Parent_3	Files	28877 chars	0.8367	99.14	2.27	96.87	0.86	0.85	0.01	94.74	99.14	100.00
Positive Reac	Parent_3	Files	28877 chars	0.6735	98.03	2.12	95.91	1.97	1.96	0.01	93.96	98.03	100.00
Source	Parent_3	Files	28877 chars	0.63	97.79	1.96	95.83	2.21	2.21	0	94.03	97.79	100.00
Stress	Parent_3	Files	28877 chars	0.922	99.19	5.06	94.13	0.81	0.8	0.01	89.66	99.19	100.00
Support	Parent_3	Files	28877 chars	0.6824	89.59	15.43	74.17	10.41	4.44	5.97	67.25	89.59	100.00
Toys	Parent_3	Files	28877 chars	0.4057	96.71	1.17	95.54	3.29	0	3.29	94.47	96.71	100.00
Trust	Parent_3	Files	28877 chars	0.9559	99.89	1.26	98.63	0.11	0.11	0	97.40	99.89	100.00
Negative	Parent_3	Files	28877 chars	1	100	0	100	0	0	0	100.00	100.00	100.00
NegativeMod	Parent_3	Files	28877 chars	1	100	0	100	0	0	0	100.00	100.00	100.00
NegativeVer	Parent_3	Files	28877 chars	1	100	0	100	0	0	0	100.00	100.00	100.00
Positive	Parent_3	Files	28877 chars	1	100	0	100	0	0	0	100.00	100.00	100.00
PositiveMod	Parent_3	Files	28877 chars	1	100	0	100	0	0	0	100.00	100.00	100.00
PositiveVery	Parent_3	Files	28877 chars	1	100	0	100	0	0	0	100.00	100.00	100.00
Average for node "Community\Community change" (unweight				0.8026	97.36	5.90	91.46	2.65	1.32	1.33	86.61	97.36	100.00
Average for all nodes & sources (unweighted)				0.7739	97.47	4.67	92.80	2.53	1.14	1.39	88.83	97.47	100.00

Code	File	File Folder	File Size	Kappa	Agreement (%)	A and B (%)	Not A and Not B (%)	Disagreement (%)	A and Not B (%)	B and Not A (%)
Adaption	Parent_6	Files	28877 chars	-0.0198	96.11	0	96.11	3.89	1.89	1.99
Annoyance	Parent_6	Files	28877 chars	1	100	0	100	0	0	0
Breathing Excercise	Parent_6	Files	28877 chars	1	100	0	100	0	0	0
Coping Method	Parent_6	Files	28877 chars	0.6156	92.1	7.56	84.54	7.9	1.04	6.86
Digital Entertainment	Parent_6	Files	28877 chars	0.527	94.28	3.51	90.77	5.72	5.72	0
Fear	Parent_6	Files	28877 chars	1	100	0	100	0	0	0
Feelings	Parent_6	Files	28877 chars	0.4708	99.09	0.41	98.67	0.91	0	0.91
Group Activities	Parent_6	Files	28877 chars	0.7356	97.76	3.31	94.45	2.24	1.53	0.71
Growth	Parent_6	Files	28877 chars	0.3062	87.17	3.86	83.31	12.83	4.88	7.95
Hard to understand	Parent_6	Files	28877 chars	0.6788	96.55	3.93	92.62	3.45	0	3.44
Home	Parent_6	Files	28877 chars	0.7161	96.78	4.4	92.38	3.22	0.01	3.21
Involvment	Parent_6	Files	28877 chars	0.9976	99.99	2.97	97.01	0.01	0.01	0
Knowledge	Parent_6	Files	28877 chars	0.638	92.94	7.42	85.51	7.06	3.37	3.7
Motivation	Parent_6	Files	28877 chars	0	99.72	0	99.72	0.28	0	0.28
Negative Reaction	Parent_6	Files	28877 chars	0.9969	99.99	1.68	98.31	0.01	0.01	0
Nothing	Parent_6	Files	28877 chars	1	100	0	100	0	0	0
Positive Reaction	Parent_6	Files	28877 chars	0.7952	99.44	1.12	98.32	0.56	0.26	0.31
Source	Parent_6	Files	28877 chars	0.9973	99.99	1.96	98.03	0.01	0.01	0
Stress	Parent_6	Files	28877 chars	0.9226	99.2	5.06	94.14	0.8	0.8	0
Support	Parent_6	Files	28877 chars	0.4698	87.58	6.96	80.61	12.42	0.97	11.45
Techniques	Parent_6	Files	28877 chars	0.597	98.35	1.27	97.08	1.65	0.87	0.79
Toys	Parent_6	Files	28877 chars	0	95.99	0	95.99	4.01	0	4.01
Trust	Parent_6	Files	28877 chars	-0.0232	92.02	0	92.02	7.98	1.37	6.6
Negative	Parent_6	Files	28877 chars	1	100	0	100	0	0	0
Negative\Moderately	Parent_6	Files	28877 chars	1	100	0	100	0	0	0
Negative\Very negat	Parent_6	Files	28877 chars	1	100	0	100	0	0	0
Positive	Parent_6	Files	28877 chars	1	100	0	100	0	0	0
Positive\Moderately	Parent_6	Files	28877 chars	1	100	0	100	0	0	0
Positive\Very positiv	Parent_6	Files	28877 chars	1	100	0	100	0	0	0

Appendix F

Survey Questions for Prototype Testers

1. What gender do you identify as?
    a. Male
    b. Female
    c. Other
    d. Prefer Not to Answer
2. What is your age?
3. Which categories describe you? Please select all that apply?
    a. White
    b. Hispanic, Latino, or Spanish origin
    c. Black or African American
    d. Asian
    e. American Indian or Alaska Native
    f. Middle Eastern or North African
    g. Native Hawaiian or Pacific Islander
    h. Some other race, ethnicity, or origin
4. How well do you feel you know Nurse Jen?
    a. 1: Do not know
    b. 5: Know very well
5. How much do you trust Nurse Jen
    a. 1: No trust
    b. 5: Complete trust
6. How Helpful Was Nurse Jen
    a. 1: Not Helpful
    b. 5: Very Helpful
7. How well do you feel you know Nurse Suzy?
    a. 1: Do not know
    b. 5: Know very well
8. How much do you trust Nurse Suzy
    a. 1: No trust
    b. 5: Complete trust
9. How Helpful Was Nurse Suzy
    a. 1: Not Helpful
    b. 5: Very Helpful
10. How satisfied were you with customising your bear?
    a. 1: Very Satisfied
    b. 5: Not Satisfied
11. How satisfied were you with the App?
    a. 1: Very Satisfied
    b. 5: Not Satisfied
12. How distracted did you feel while using the App?
    a. 1: Not Distracted
    b. 5: Very Distracted

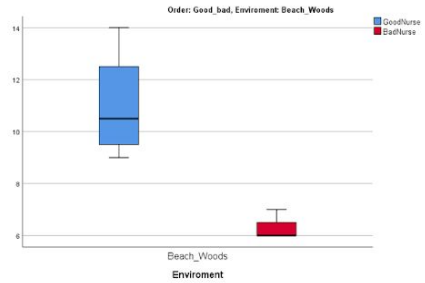
Appendix G

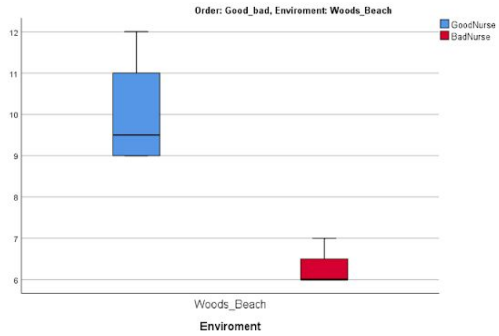
Samples of Data Collected from Prototype Testing

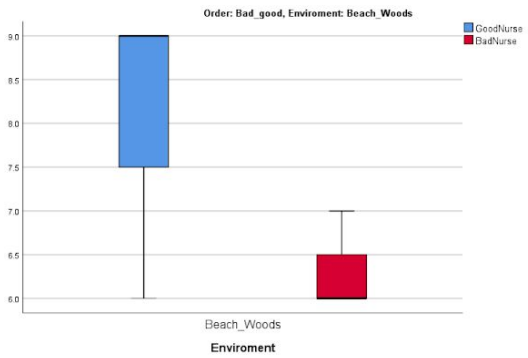
Sample of raw data:

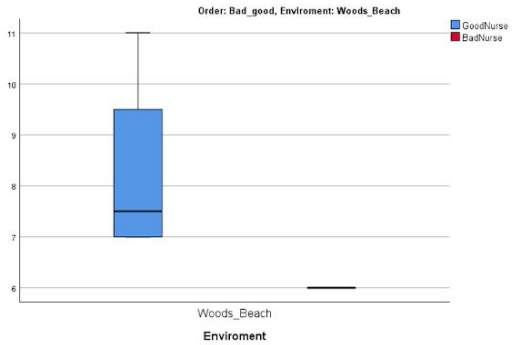
	Bear Items		Parent Section		Virtual World					
Test Number	Appearance	Medical	Time (Secs)	# of Errors	Time Good (secs)	Time Bad (secs)	# of Clicks Good	# of Clicks Bad	# of Errors Good	# of Errors Bad
1 (1)	3	2	19	2	54	27	14	13	3	6
4 (1)	2	0	22	0	50	28	9	7	2	0
5 (1)	3	2	8	3	24	28	6	6	1	1
8 (1)	3	2	16	0	17	18	7	6	0	0
7 (1)	5	2	20	0	24	20	7	6	1	0
2 (1)	4	0	6	0	21	19	10	6	3	0
3 (1)	2	1	16	0	39	26	10	6	1	0
6 (1)	3	1	28	0	26	22	9	6	1	0
8 (2)	3	1	17	1	24	21	8	6	1	0
1 (2)	4	2	22	0	42	20	11	7	2	0
6 (2)	4	1	13	0	29	23	9	6	0	0
5 (2)	3	1	16	1	33	21	9	7	1	0
7 (2)	4	0	26	1	26	24	11	6	3	0
3 (2)	4	2	26	0	49	25	9	6	2	3
4 (2)	3	2	16	0	43	20	12	6	1	0
2 (2)	2	2	9	0	47	25	9	6	3	0

Examples of statistical analysis plots:









Tests of Normality[a]

	Enviroment	Kolmogorov-Smirnov[b] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
GoodNurse	Beach_Woods	.250	4	.	.927	4	.577
BadNurse	Beach_Woods	.441	4	.	.630	4	.001

a. Order = Good_bad, Enviroment = Beach_Woods

b. Lilliefors Significance Correction

Tests of Normality[a]

	Enviroment	Kolmogorov-Smirnov[b] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
GoodNurse	Woods_Beach	.260	4	.	.827	4	.161
BadNurse	Woods_Beach	.441	4	.	.630	4	.001

a. Order = Good_bad, Enviroment = Woods_Beach

b. Lilliefors Significance Correction

Tests of Normality[a]

	Enviroment	Kolmogorov-Smirnov[b] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
GoodNurse	Beach_Woods	.441	4	.	.630	4	.001
BadNurse	Beach_Woods	.441	4	.	.630	4	.001

a. Order = Bad_good, Enviroment = Beach_Woods

b. Lilliefors Significance Correction

Tests of Normality[a]

	Order	Kolmogorov-Smirnov[b] Statistic	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
GoodNurse	Bad_good	.303	4	.	.791	4	.086
BadNurse	Bad_good	.	4	.	.	4	.

a. Order = Bad_good, Enviroment = Woods_Beach

b. Lilliefors Significance Correction

Levene's Test of Equality of Error Variances[a]

		Levene Statistic	df1	df2	Sig.
GoodNurse	Based on Mean	.211	3	12	.887
	Based on Median	.222	3	12	.879
	Based on Median and with adjusted df	.222	3	11.157	.879
	Based on trimmed mean	.198	3	12	.896
BadNurse	Based on Mean	3.000	3	12	.073
	Based on Median	.333	3	12	.802
	Based on Median and with adjusted df	.333	3	9.000	.802
	Based on trimmed mean	2.253	3	12	.135

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Order + Enviroment + Order * Enviroment
Within Subjects Design: Typeofnurse

Mauchly's Test of Sphericity[a]

Measure: numberofclicks

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b] Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Typeofnurse	1.000	.000	0	.	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept + Order + Enviroment + Order * Enviroment
Within Subjects Design: Typeofnurse

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Tests of Within-Subjects Effects

Measure: numberofclicks

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Typeofnurse	Sphericity Assumed	81.281	1	81.281	48.466	.000	.802
	Greenhouse-Geisser	81.281	1.000	81.281	48.466	.000	.802
	Huynh-Feldt	81.281	1.000	81.281	48.466	.000	.802
	Lower-bound	81.281	1.000	81.281	48.466	.000	.802
Typeofnurse * Order	Sphericity Assumed	9.031	1	9.031	5.385	.039	.310
	Greenhouse-Geisser	9.031	1.000	9.031	5.385	.039	.310
	Huynh-Feldt	9.031	1.000	9.031	5.385	.039	.310
	Lower-bound	9.031	1.000	9.031	5.385	.039	.310
Typeofnurse * Enviroment	Sphericity Assumed	.281	1	.281	.168	.689	.014
	Greenhouse-Geisser	.281	1.000	.281	.168	.689	.014
	Huynh-Feldt	.281	1.000	.281	.168	.689	.014
	Lower-bound	.281	1.000	.281	.168	.689	.014
Typeofnurse * Order * Enviroment	Sphericity Assumed	.781	1	.781	.466	.508	.037
	Greenhouse-Geisser	.781	1.000	.781	.466	.508	.037
	Huynh-Feldt	.781	1.000	.781	.466	.508	.037
	Lower-bound	.781	1.000	.781	.466	.508	.037
Error(Typeofnurse)	Sphericity Assumed	20.125	12	1.677			
	Greenhouse-Geisser	20.125	12.000	1.677			
	Huynh-Feldt	20.125	12.000	1.677			
	Lower-bound	20.125	12.000	1.677			

Tests of Within-Subjects Contrasts

Measure: numberofclicks

Source	Typeofnurse	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Typeofnurse	Linear	81.281	1	81.281	48.466	.000	.802
Typeofnurse * Order	Linear	9.031	1	9.031	5.385	.039	.310
Typeofnurse * Enviroment	Linear	.281	1	.281	.168	.689	.014
Typeofnurse * Order * Enviroment	Linear	.781	1	.781	.466	.508	.037
Error(Typeofnurse)	Linear	20.125	12	1.677			

Tests of Between-Subjects Effects

Measure: numberofclicks

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	1937.531	1	1937.531	1184.732	.000	.990
Order	11.281	1	11.281	6.898	.022	.365
Enviroment	.781	1	.781	.478	.503	.038
Order * Enviroment	.281	1	.281	.172	.686	.014
Error	19.625	12	1.635