CubeBuddy
Distance play and communication platform for hospital settings

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**IMPETUS**

While growing up I was hospitalized several times for different medical reasons, fortunately none of them was a serious illness but the hospitalization period was very stressful. Also, both my parents had cancer during my teen years, so did my grandfather, my aunt, my cousins and other family members. For this unfortunate reason hospitals and cancer have been a major part of my life. Through these experiences, I always felt that feelings of loneliness while staying in the hospital are the most difficult part.

Games and toys, that offer educational, assistive and therapeutic opportunities, are my main personal and professional interests. CubeBuddy project grows from my background, academic and professional interests, and future career plans. CubeBuddy ties all of these areas together. I am interested in studying the fields of games and play, and especially in combination within education and health-care. The impetus for the project comes from both my personal interest in designing specialized toys and my passion and dedication that derive of my family background - making a valuable contribution to the cancer society.
THESIS CONCEPT

CubeBuddy is a two player gaming and communication platform designed for children ages 10-18, with limited opportunities for social play and peer interaction. It focuses particularly on children who are hospitalized and enduring extended hospital stays in isolated rooms. This project is designed to address feelings of isolation and provide new opportunities for cooperative distance play within the limitations of the medical condition and hospital settings.

Through play the CubeBuddy provides a unique frame for young patients to connect to each other via colored lights and sounds. CubeBuddy is a 6×6” soft, white electronic cube with colorful trimming. Its material is Tyvek, which can be wiped clean and sterilized. Despite being a cube, the toy playfully suggests human characteristics through its two floppy legs but still leaves space for imagination and personal customization with stickers or markers. A wireless module installed in each cube enables its communication features. Interaction with the cubes results in auditory and visual feedback through colored light and sound.

In the future CubeBuddy will be enabled for Internet connection, expanding its distance range and providing new opportunities for games and communication. Also, audio-verbal communication will be added to the feature set.

Personal experience of hospitalization and hospitalized family members and friends in combination with the interviews and observation at the Montefiore Children’s Hospital defined the goal of this thesis project. From observation and interview with Meghan Kelly, The Child Life Program Director there, I found a lack of social interaction among the hospitalized children (ages 10 -18), especially those enduring extended stays. This problem is even worse for patients staying in the isolation rooms. The goal became to find a way to increase the opportunities for social interaction.
Between ages 10 -18 interaction with peers has a crucial role in developing social skills. Extended stays in hospital and specifically in isolation-rooms limit the opportunities for connection between children just when they need it most. The importance of peer interaction is heightened in the case of serious illness as described in *Psychosocial Aspects of Pediatric Oncology*, “Peer support was consistently and significantly associated with psychological adjustment measures at a greater magnitude than other perceived social domains, namely that of parents and teachers. Hogher perceived social support was associated with fewer depressive symptoms, lower state, trait and social anxiety, higher general self-esteem, and lower acting out behavior and a lower perception of stressors associated with cancer and the side effects of chemotherapy yielding a lower negative affectivity score”\(^1\).

Play is an efficient ways to encourage social interaction and enhance communication between peers. Katie Salen and Eric Zimmerman in their book *Rules of Play*, break the concept of play into three categories:

- **Game Play**: the formalized, focused interaction that occurs when players follow the rules of a game in order to play it.
- **Ludic Activities**: non-game behaviors in which participants are “playing”, such as two tussling animals or a group of children tossing a ball in a circle. Game play is a subset of ludic activities.
- **Being Playful**: the state of being in a playful state of mind, such as when a spirit of play is injected into some other action. This category includes both game play and ludic activities. \(^2\)

CubeBuddy combines all these categories in different variations. It provides a platform for games with defined rules and goals. While being played just by one child it takes form of an interactive toy. And perhaps most importantly it affords playful

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communication between isolated children. As Salen and Zimmerman write, "While there are notable exceptions, such as solitaire card games, by and large over the centuries games have been valued as social experiences, as a way for people to relate to each other, as a way for people to play together."\footnote{Katie Salen and Eric Zimmerman, \textit{Rules of Play} (Cambridge, Massachusetts: The MIT Press, 2004).} Understanding the important role of play in social interaction is one of the main elements behind developing CubeBuddy. On the other hand, Stuart Brown in book \textit{Play}, instead of directly defining play, suggests a definition for the properties of play: "Apparently purposeless (done for its own sake), voluntary, inherent attraction, freedom from time, diminished consciousness of self, improvisational potential, continuation desire."\footnote{Stuart Brown, \textit{Play} (New York, NY: Avery, Penguin Group, 2009).} The CubeBuddy project strives to embody all the properties of play described above.

The hospital setting provided several design constraints. Any object in an isolation room has to be easy to clean and sterilize. Play had to consist of simple motor tasks and easy to understand game rules to meet the physical, emotional and mental needs of seriously ill patients. A further restraint dictated by the players’ illnesses required that they should be given the opportunity stop playing at any moment and resume the play at a later time. Also, the production cost is very important aspect take into consideration while designing for a hospital setting. The hospitals are very depended on funders and have very limited financial resources. Within all these restrictions it has to provide a fun play activity, and engage a wide range of ages, different genders and cultures.

The target user age range for CubeBuddy is very broad. The reason for this is that children’s hospital setting brings together a wide age range of children, and the combinations of the ages in the group constantly change. There is no way to specify a narrow age group for every play instance. Besides the different age groups, the game designed to be played by children who are coming from different backgrounds and physical conditions.
The open-ended design of CubeBuddy affords a wide target age group, from ages eight to eighteen. CubeBuddy is accompanied by a booklet, which provides predefined communication signals and preinstalled games rules. The booklet defines just minimal and very basic possible signals; more is opened to users interpretation and development throughout the play. The simple, interactive interface of CubeBuddy enables further development of games by the user just by creating their own rules and game mechanics to use the same illuminating LEDs and sound feedbacks.

CubeBuddy enables a compelling form of collaborative distance play as a communication. Its feature set is designed to allow for the creation of new games. CubeBuddy is an adjustable gaming platform that can be played in different levels and bridge a wide age group. In contrast to existing screen-based social networks CubeBuddy provides a tactile and comforting experience for distance play and communication.

As part of further development the network will be connected through the Internet and will open the game to children outside the hospital. Verbal audio connection is another aspect that will be developed.
PRECEDES AND DOMAINS

CubeBuddy is a project that evolved out of a need that I recognized within the health care domain. The suggested solution to this problem is a combination of different research domains, as toys, games, psychology and technology. To gain a better understanding of the background for my project, I performed a wide range of research within these different disciplines and different previous projects or products, related in various ways to my own project.

The starting point of the research was contacting Meghan D. Kelly, MS, CCLS, and director of Child Life Program & Carl Sagan Discovery Program at The Children's Hospital at Montefiore. Kelly and the Oncology-Hematology Pediatric Unit at CHAM became an extensive source of research information and provided observation and user testing opportunities throughout the whole thesis process.

The children’s hospital: Its interior design and planning of the hospital are very impressive. The lobby is very bright with huge windows, the ceilings are tall and the colors of the walls are bright. There are pictures of children on the walls. The main decoration motifs are sky, water, nature, science and smiling kids. The atmosphere is very calm and relaxing. That experience contradicted any previous hospital experiences.

Child life program in Children's Hospital at Montefiore: The initial thesis research led to the Child Life Council and particularly Child Life Program in Children's Hospital at Montefiore and Child Life Specialists. The Child Life Council is a worldwide organization that supports children experiencing stress and trauma, especially during sickness and hospitalization. They aim to create child
and family friendly hospital environments.

**The Life Program:** The Child Life Program is a combination of health care, education and play. The Life Program specialist job is an evolving profession that requires more and more awareness. Nowadays every hospital in the USA is required to have a life specialist. The role of a Life Program specialist is to help children cope with medical procedures and any other aspect of their illness. Through education and play, the Child Life specialist helps the children feel more in control and reduces their fears. The life specialist’s role is not to entertain or be a solution to boredom. The Life Program provides different activities such as: art therapy; group or individual activity, play therapy; group or individual activity, music therapy; group or individual activity, hospital procedures simulation; group or individual activity.

The Child Life Program is a special program that “recognizes the unique emotional and developmental needs of children and their families throughout their healthcare experience. The role of the Child Life Program is to help children successfully cope with illness, injury and treatment so that they may continue to live normal lives during their healthcare experience”\(^5\). The visits at CHAM were a very important part of the research. During my visits I met with Kelly and Lindsay Davis one of the Child life specialists. They both spent a lot of time with me, showing me around and providing extremely informative details about the program and the unit. The visits provided valuable information about methods, toys and activities that they currently use in the hospital.

**Equipment, toys, games or tools:** One of the main impressions from the unit was the enormous amount of toys and games. Most of them are located in the playroom. There are regular toys, art accessories and popular children’s games. But there are many hospitals themed and oncology specialized toys as well.

There are many modulations for different therapy equipment and therapy rooms. Lindsay, the life specialist mentioned that often they have to be very creative and improvise their own modifications for the children.

Teddy Bear Clinic: As it appears on the abclocal.go.com website; “Teddy bear is typically a universal symbol of comfort. It is something kids usually associate good thoughts with. And that's the thinking behind a special program at the Children's Hospital at Montefiore, where the little ones step into”

Teddy Bear Clinic is very similar to my initial thesis idea. My first concept was designing an interactive toy that will help children to learn about their body and the process that it goes through during the physical therapy. I was exposed to Teddy bear clinic at the first steps of my research. It inspired me a lot and forced me to expand the research for different contexts.

Shadow Buddy: The Shadow Buddy is a personal doll that is given to every hospitalized child in the unit. The shadow Buddy as its name suggests, “shadows” the ill child through out the disease. The Shadow Buddy is a fabricated soft doll. There are Shadow Buddies from different races and genders. Some of the dolls come without a face, which allows the child create his own personal character.

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Some of the shadow buddies have different medical installments such as an IV connection or different bandages. The children often “practice” their medical procedures on the Shadow Buddies. By doing this they get a better understanding of what they will have to deal with. It gives them more control over the situation and reduces stress. Other times the child repeats the procedures that he already went through. If the child had a painful or very stressful experience repeating it on the doll gives them the opportunity to deal with this fear again, as well as express their feelings and fears. Besides the small shadow buddies there are much bigger dolls with more advanced installments on them.

**The Medikins:** The therapist usually uses The Medikins with a group of children. As Lindsay, the Child Life specialist noted, “very often the older children like to take the therapist role and show to the younger children how well they know to perform the medical procedures on these dolls.”

**Virtual reality games to manage pain felt by burn patients during wound care and physical therapy:** as mentioned on the ScienceDaily website, “SnowWorld, an interactive, virtual-reality video game being used at Loyola University Hospital in Maywood, Ill., to manage pain felt by burn patients during wound care and physical therapy…. Treatment of burn injuries can be excruciating. It often involves daily bandage changes, the cleaning of wounds and the removal of dead tissue in order to stave off infection and prevent scar tissue from forming. Also, a burn patient’s skin must be stretched in order to restore and maintain the range of motion, minimize muscle atrophy and reduce the need for further grafts. The virtual-reality system eases pain of treatment by immersing burn patients in a wintry, computer-generated environment. Its interactive, multi-sensory, features put patients in a deep freeze of distraction, leaving less attention for the processing of incoming pain signals. It’s similar to what has been done with music, movies and even two-dimensional
video games, but more effective because it involves problem-solving activities that emphasize coolness.”7 This project has exposed me to the broader play concept. Focusing on developing toys but learning about other games as play therapy has expanded my observation range.

“Paro” therapeutic robot: “PARO is an advanced interactive robot developed by AIST, a leading Japanese industrial automation pioneer. It allows the documented benefits of animal therapy to be administered to patients in environments such as hospitals and extended care facilities where live animals present treatment or logistical difficulties. Paro is the 8th generation of a design that has been in use in Japan and throughout Europe since 2003. Paro has five kinds of sensors: tactile, light, audition, temperature, and posture sensors, with which it can perceive people and its environment. With the light sensor, Paro can recognize light and dark. He feels being stroked and beaten by tactile sensor, or being held by the posture sensor. Paro can also recognize the direction of voice and words such as its name, greetings, and praise with its audio sensor.

Paro can learn to behave in a way that the user prefers, and to respond to its new name. For example, if you stroke it every time you touch it, Paro will remember your previous action and try to repeat that action to be stroked. If you hit it, Paro remembers its previous action and tries not to do that action. By interaction with people, Paro

responds as if it is alive, moving its head and legs, making sounds, and showing your preferred behavior. Paro also imitates the voice of a real baby harp seal.”

“Paro” is a very advanced technological project. Besides providing an inspiration, the creators provide a lot of interesting academic-research information per request. “Paro” is less than a toy, but more of a friend, a mental support. It’s almost a living creature. The success of this project emphasizes the importance of mental and social support for the patient.

Toys and technology for rehabilitation in Cerebral Palsy patients: as quoted from parorobots.com website “Therapeutic toys, designed as therapy for children with cerebral palsy (CP)... Physical and occupational therapy have been shown to be effective treatments in improving function, however, Karen Kerman, M.D., director of the pediatric rehabilitation center at Hasbro Children's Hospital, wanted to find a way to incorporate physical therapy into the normal activity of children - play.”

This project highlights the important contribution of play to the heath care system. I believe that contacting this program might provide me with a lot of valuable information for my own project.

The Cancer Game, By Yuko Oda and Dave Kristula: Is a side-scrolling, arcade-style, cancer fighting video game. The game has a very simple interface, rules

and goals. By using the keyboard arrows and the space bar the player moves around the screen and shoots roaming cancer cells. This very simple action designed help to deal with the frustration and the anger with fighting cancer. The game might be paused at any time and will continue from the same place when the player will be back to play. This is a very important element of the game since the players that undergoing cancer treatment tend to get tired very often or have to stop their activities while they need to receive a medical treatment. The game is very simple to play and win which is very important for not add any unnecessary frustrations to the user.

All these aspects of the cancer game have a significant impact on CubeBuddy. Latest prototypes tried to simplify as much as possible the interface, the rules, and the game play. Another aspect is to enable a relatively quick game and make it possible join and quit the game at any moment.

The research about current toys, games and tools in the hospitals shows that there are many existing precedents for using play within health care. However, most of them are pursuing medical-educational or therapeutic goals. Social interaction and peer support do not have many hospital settings adjusted solutions.

Starlight Children's Foundation: Is improving the quality of life for children with chronic and life-threatening illnesses and life-altering injuries by providing entertainment, education and family activities that help them cope with the pain, fear and isolation of prolonged illness. Starlight provides family activities, in-hospital entertainment technology, online communities and interactive websites in-hospital playrooms,

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kid-friendly treatment rooms and special events and Educational programming.

Starbright World is a very important accomplishment by Starlight. Starbright World is an online social network where teens (ages 13 to 20) who have serious medical conditions, and siblings of seriously ill teens, can connect with each other via moderated chat rooms, games, bulletin boards, videos, and more. “Starbright World is a virtual hangout where teens can build on existing friendships or create new ones, from home or from the hospital.”

Starbright World provides a very important reference for CubeBuddy. It suggests online activities for peer interaction between the hospitalized and seriously ill children and teens. In contrast to Starbright World as it creates a social network, CubeBuddy suggests a tangible, playful interaction.

After looking into toys and games that exist in the health care, the next step was to research and learn projects that have been done in the remote play realm. The focus is on tangible interfaces projects. The goal of CubeBuddy is to find a way to use the remote play and communication ideas within the restrictions and the needs of the design for hospital settings.

Brick-Building Interface Support for Cocreative Communication: “To support cocreative communication between people who are in separate, remote locations, embodied communication is crucial and a common place for communication should be established. This article proposes an idea to integrate remote, physically restricted places into a shared virtual space to bridge these remote places

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and to describe interface systems for cocreative communication. To show a typical example of cocreative communication with a high degree of freedom for bodily actions, this study focused on brick-building play, in which people are free to construct structures spatially with physical objects. For remote collaborative communication including modeling with physical bricks at each physical place, two interface systems were designed: the brick-modeling interface system and the brick-reader glove interface system. The brick-modeling interface system makes it possible for users to act out others’ brick plays with physical bricks in the remote places and in shared virtual space in real time. The brick-reader glove interface system enables users to act out the modeling process with virtual bricks and virtual avatars of both remote users in the shared virtual space. The experiment clearly suggests that these interface systems are useful for creating a shared virtual space and for supporting collaborative work in three dimensions with a sense that the remote people were together in the same place.\textsuperscript{13}

This is an outstanding project, which has a direct relevancy to the CubeBuddy idea of a distant collaborative play. The project realizes the importance of connecting people from distant locations as well as the importance of an interaction with physical objects. These ideas are a great support for my own thesis idea. The Brick-Building interface creates a virtual reality environment, which is not the purpose of CubeBuddy, which aims to create a wireless connection from distance using real physical objects as connectors, but it does use physical objects as a core idea.

The following two projects are precedents for a development and a study of using tangible interfaces for remote play. Both of these projects are designed for younger children and encourage an imaginative play.

Toys Keeping in Touch: Technologies for Distance Play (Natalie Freed): “A remote communication system designed to facilitate imaginative play using the novel approach of a tangible interface specifically for character toys. A dollhouse enhanced with tangible electronic objects that allow the toy inhabitants of the house to communicate with the inhabitants of a remote dollhouse was constructed and evaluated in a pilot study.”14

PlayPals, Tangible Interfaces for Remote Communication and Play:
“PlayPals are a set of wireless figurines with their electronic accessories that provide children with a playful way to communicate between remote locations. PlayPals is designed for children aged 5-8 to share multimedia experiences and virtual co-presence.”15

Breakout for Two16 and Remote-Impact17 projects by Distance Lab Europe are great examples for using tangible interfaces for remote play. Breakout for Two creates a physical, competitive game-play between participants in remote locations. The game requires real physical activity when players in remote locations kick a real soccer ball to break a projection of virtual block wall. Remote-Impact is another sport game played over distance. The players are boxing with each other by hitting a virtual projection of the other player’s silhouette on a soft mattress wall. Both of these projects bridge over distance by physically involved play through real, tangible objects and interfaces.

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The next step of the research came later on into the prototyping process, when CubeBuddy became more of a platform and simplified into a cube shape. As a gaming open-ended platform CubeBuddy is designed to host different games. The games will be using its simple cubical interface that provides colorful light and sound feedback. For that reason the research advanced to the exploration of different existing games that can be modified for the interface of CubeBuddy or provide inspiration for designing new games uniquely for CubeBuddy. The preference was towards games that are popular among the children and they already familiar with the game mechanics. The familiarity with the games will help and shorten the adjustment to the interaction with CubeBuddy’s interface.

**Simon Says:** As described on the group-games.com website, Simon Says is “A classic kids icebreaker/stationary game in which the leader, Simon, instructs people to do various actions. The goal is to only do something when Simon says so, and to do nothing when he doesn’t.”\(^\text{18}\) It’s simple and adjustable to different ages and group sizes, which is exactly what CubeBuddy aims to do. A variant of Simon Says might be played on CubeBuddy.

**Simon Says electronic memory game:**\(^\text{19}\) This game is very close to the games idea that I’m interested in for the Interactive Cubes. In this electronic version of Simon Says, the device takes the leading role, and player follows its instructions by interacting with colorful, illuminating buttons and musical sounds. Unlike this game, CubeBuddy is a tool that the actual player uses to lead other players.

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**Battleship:** Battleship is a classic board game, which started as a paper and a pencil game and developed into different electronic and online variants. It’s a two-player, guessing and strategy game. The main interface of the game consists of four boards, usually divided into a 10x10 grid. Each player has two boards, which are used to place different sized battleships. On one of the boards each player will place his own ships, the other board the player will use to guess and map his opponent’s ships. The goal of the game is to locate and sink opponent’s ships by shooting missiles to different coordinates on the board, each turn. The usage of a grid and coordinates on the grid to guess the locations of the ships on the opponent’s board is a very similar idea to one used with CubeBuddy. It is interesting how the Battleship game is played between two players who are usually physically present in the same room and they create artificial barriers to enable the guessing game mechanics. While CubeBuddy deals with a given situation of a distance and use the guessing game mechanics as a communication bridge.

Besides the games, the research focused on different devices and toys that using an interface that reminds the interface of CubeBuddy. That was important for a better understanding of using a simple button-LED-sound interface for interaction.

**Monome:** is a matrix of buttons of LEDs that can be controlled via Open Sound Control or MIDI data protocols via USB to a computer. Basically it is an adjustable controller with a very playful and interactive interface. As said by the creators of the Monome “We seek less complex, more versatile tools: accessible, yet fundamentally adaptable. We believe these parameters are most directly achieved
through minimalistic design, enabling users to more quickly discover new ways to work, play, and connect. We see flexibility not as a feature, but as a foundation.”

**Electronic Rubik’s Cube Variants**

**Rubik's Revolution:** An electronic Rubik’s Cube variant, which adopts 6 different games. The mechanics of all the suggested games on this cube are very different from the original Rubik’s cube. The interaction is through sound light and touch. This device is an interesting attempt to create an adoptable interface for a game platform, which I personally feel is not being fully explored in this cube. The six different suggested games are very similar to each other and even the multi player game feels to me a bit forced on the device. It’s a good chance for me to learn from what I think doesn’t succeed within this device and implement the conclusion in designing CubeBuddy.

**New Rubik’s Touch:** The Rubik’s Touch is a new electronic interactive toy, which has the same game mechanics as the old fashion Rubik's Cube but with an advanced interactive touch features.

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METHODOLOGY

The methodology of developing CubeBuddy consisted of iterative process of conceptual development, prototyping, testing and evaluation for further development. The process started from testing the basic concept of distance play and it evolved into developing multiple variations of gaming interfaces and mechanics. The developing of Cubebuddy was a learning curve of designing with strict restrictions and needs that come out of the hospital setting limitations and medical condition.

After studying the precedents, hospital settings, user target and formalizing the concept, the basic idea of the thesis concept was tested - a physical board game played from distance, online.

First Prototype:

A board game that my brother and I used to play when we were children was chosen for the test. This is an Israeli board game called The Mall. It is similar to Monopoly but its objective is the exact opposite. You start the game with a certain amount of money and your goal is to spend all of it in that cardboard mall. Rolling dice and performing the tasks of different cards move the counters forward. My brother set up the board at his home (Israel) and we started to play via Skype. I didn’t have real dice so I used an IPhone application to roll. My brother was the activator of all my actions, so I would basically just roll the dice and he would do the
rest of my actions. In spite of the distance and all the barriers we actually had fun playing.

What worked well?
- Rolling the dice was a very simple action to communicate via Skype, even though an IPhone dice were used.
- My brother always could see me rolling the dice and the results.
- To communicate the information on the cards and on the board was relatively easy.
- Being able to respond visually and by speech to each others actions contributed to the fun.
- By my brother pretending to be me added some acting aspects to the game.
- Being able to see the whole board and all the pieces. Contributed to the feeling of almost being physically present in the same room.

What didn’t work?
- Sometimes I felt a bit useless, or as if my hands were tied.
- My brother was the one who had to enact all his and my actions, which felt tedious at times.
- I felt occasionally disconnected from the game.
- I had to depend on my brother through the whole game.

Paper Board Games Prototypes:
After evaluating the first online-via Skype, board game prototype the idea of a collaborative, wireless game board started to develop further. Board game is one of the most socially bonding forms of play and there are significant advantages to the use of board games in the play-therapy field. The main goals that were set for the game at this stage: provide opportunities for social interaction, educate about the medical condition, treatments, hospital setting and help children cope with stress and fears. Prototypes of different games ideas and mechanics started to develop. Variety of different paper prototypes of 4 players board game were created. The main design concept for all these
paper prototypes was four syncing game boards with a 3-D paper figures. After number of paper prototypes and their evaluation, came the realization that the communication, which is the main goal of this game hasn’t been achieved yet. The immediate resolution to this problem was adding a sound, speech communication. Four walky-talkies devices that can be operated on the same channel were purchased. The walkie-talkies became a very important part of the game and the game mechanics started evolve from it.

Very challenging goals to achieve with the game were set, an attempt to combine different aspects from the research, such as: communication, education, therapy, and distraction into one game. Within the process it became clear that all these aspects couldn’t be achieved fully in just one board game. The first, important turning point for me came when I got a cold and stayed home feeling very sick and tired. Ironically, I was very fortunate to get sick at this point. That was an unexpected opportunity to get a whole new viewpoint on the game. While being sick is very difficult and almost impossible to play such a complicated game, or think about game strategies, as all of the prototypes require the user to do. Realizing that, the game started to simplify, certain goals as therapy and education were dropped out, concentrating on the main idea of it- providing a safe opportunity for peer’s social communication and enhancing it. After a few prototypes of a simplified version of the game a new problem appeared, suddenly the idea of making it a board game didn’t seem right anymore. It felt that at this point the board idea was forced on the thesis concept.
A step back was taken and the whole process was reevaluated. This was a major turning point. A result of this process was a new set of goals and outlines for the project:

- Simple motor tasks
- Simple game rules
- Adjustable play time
- Easy to clean / sterilize
- Encouraging Communication
- Flexible number of players
- FUN

**New Direction:**

Refining the goal of the game, the needs and the limitations of the hospital setting, and the user target, evolved a new idea of creating a communication device with a simple interface of a cube divided by grid. Beyond being a communication tool, the device acts as a gaming platform, which uses games to provide a safe and fun communication frame.

In purpose to take forward this new idea, a new prototype was made and tested. For this iteration, the prototype was two paper cubes and walkie-talkies. A user/audience experience was tested mainly. The idea of communication from a distance using walkie-talkies and achieving a collaborative goal with physical objects by using audio-verbal communication was tested. Also, in addition to the communication and collaboration test, getting feedback on the possible game mechanics using the cubes was evaluated.

Two paper identical cubes 10”x10” inches each were created. Each side of the cube has a 4x4 grid. The grid was made using illustrator software and then printed it on a tabloid size paper. The paper leftovers were folded around the grid and used to connect all the sides together. Old folder’s cardboard used to create a stronger and thicker connection between the cube sides. By using the cardboard, the cubes kept the shape in spite of their relatively big size. A stapler was used to ensure that the cube sides stay together and some tape was taped on them to make it smoother. Use of colors had an
important value through all the prototypes. After building the paper cubes, the edges of the cube were colored with markers. The frame of each side was colored with a different color. Both cubes were colored identically. Paper squares printed in colors simulated the LEDs, the buttons and the interaction with them. Paper tape used to attach the colored squares to the cubes. One cube had blue squares and the second one had green ones. During play test to simulate electronic play, the squares were attached with adhesive gum. Two walkie-talkie devices used as a communication tool. During the play-test the participants had to provide instructions to each other about where to place the opposite colors squares.

**Evaluation of the Methodology:**

Using a paper cubes and walkie-talkie worked well to simulate and test the communication between the participants. The walkie-talkie created some communication challenges, which in some cases interrupt the communication but at the same time some of the participants found it more fun. The paper cubes worked well as well to simulate the basic interaction with an object but it was hard to really simulate real electronic interaction. The feedback from pressing an electronic button was definitely missing. Another problem was to stick the squares during play. The colored squares will fall off very often and the player will lose track.

An additional conclusion from this iteration was the size of the cubes. Having the cubes physically and being able to hold them gave the idea about the size adjustments that needed to be made.

The goal of this user test was to observe the success or failure of creating a system where users were comfortable with both distant communication via walkie-talkies and secondly achieving a collaborative goal with physical objects through this audio-verbal communication. In addition to the communication and collaboration aspects of the game, feedback on the possible game mechanics with the cubes was an important aspect to test.

The test took place at Parsons, The New School at the 10th floor lab. The test was part of a play test event called Playtech. A number of kids participated, ranging in age between 14 and 20. During the Playtech event children participated in several different games tests. The prototype that was tested was combined of two paper cubes and walkie-talkies. Kurt Bieg, first year Design and Technology student was assisting during the test play. Kurt was observing and documenting through the whole test. Most of the time he was in the other room, with the second child, while they were playing. At the end of the test he provided a very valuable feedback and shared his thoughts and ideas about it.

User Test #1: 2 Brothers

Background:

The first pair of kids was two brothers. The youngest of the pair was very excited to play the game, especially after he saw the walkie-talkies devices. It seemed that the walkie-talkie device was actually the most exciting part for him. However, the older brother wasn’t so excited by the walkie-talkie or the game in general before they started to play. They had very different personalities as well, the older brother being very shy and quiet while the younger brother was very outgoing and active.
Gameplay:

The brothers had a hard time with starting the game. While the younger brother was immediately interested in the game and very intuitive with the walkie-talkies, the older brother seemed confused about the game rules and especially confused by the walkie-talkies. The younger brother definitely took a leadership role in the game and was explaining to his older brother how to play. While the younger brother immediately picked up the idea of the colors on the borders of the cube as a way to find the right coordinates, the older brother seemed to be missing it until they were interrupted and the game was explained it to him.

The test was mainly about the communication and it was very interesting to see how even two brothers with different personalities had a lot of challenges in communicating. After about five minutes they had created their own unique communication system. They started to use the colored cube boundaries to guide each other for a right direction of the cube. While at the beginning they couldn’t understand each other on the walkie-talkies, they eventually learned to take turns and could communicate effectively.

User Test #2: Group play

Background and Pre-game:

The second test turned into an unintentional group play. The group consisted of older kids, ages 17-21 4 boys and a girl. The kids faced the cubes as a group at the beginning of the game. They started a discussion that lasted about 7 minutes about a game strategy even before trying to play it. They came up with their own strategy on how to use the colored boundaries as guides for direction. Then I suggested that they split into two groups and compete with each other for a higher number of matching squares. The idea of a group competition appealed to the kids.

Gameplay:

The start of the game went mostly smoothly but still it took at least 3-5 minutes for them to get used to the walkie-talkies and the idea of being forced to talk in turns. These
kids seemed like a very active and outgoing group of kids, so taking turns talking was especially challenging for them. The first play went well, I limited the game to 3 minutes. Both teams were able to accomplish at least 8 matches. For every turn, the kids who were not playing stayed with the main players and tried to contribute and help to them by helping to rotate the cube, giving verbal instructions, and making fun of the main players’ mistakes.

After switching the main players the dynamics of the game changed. One of the main players played the first time and for the other one it was the second time. The seasoned player seemed to be impatient with the other player. At some point the kids almost got into a fight by blaming each other for the communication problems. This play test took at least half an hour and provided me with a lot of information and helpful feedback on communication aspects and the game itself.

**User Test #3:**

Pregame:

For the third play test at Playtech, the younger brother from the first test returned to play again. He paired to play with a kid who obviously wasn’t interested in the game. He immediately declared that he only plays video games. The second kid also had clear difficulty with paying attention.

Gameplay:

After several attempts at playing the game, I had to accept failure. The kid who was playing at the second time was very comfortable with the game, while the second one didn’t make any effort to contribute to the game or even to get through it. Eventually following a suggestion of their teacher, the kids sat in front of each other with both of the cubes and played it for a while. The reason for taking away the walkie-talkies was that one of the kids was extremely excited about the walkie-talkies, which distracted him a bit from the game. The second kid wasn’t motivated enough to play so the additional challenge of the communication with the walkie-talkies made it basically impossible for him to play. After the game ended I had a chance to talk with each of the groups about
the game experience.

Feedback and Conclusions:
The main problems that were observed during the game:
- The walkie-talkies work as one-way communication only, which makes the communication much more complicated.
- The current prototype was very big paper cubes (approximately 10”x10” inches each), which were a bit difficult to play with for kids with smaller hands.
- The children attached the colored squares with an adhesive gum, but it wasn’t strong enough to hold it on the box.
- Understanding a three-dimensional grid system was challenging for the kids.
- The colored borders were a bit confusing and several different participants repeated the need for the whole side to be colored.

Things that worked well and further ideas:
- The idea of a battleships-style game mechanics seemed to be fun for all the kids.
- The coordination on the cubes using a colored system is effective, though on the current prototype it was lacking because only the boundaries were colored.
- This test concentrated on communication, and on that level it was successful. During the play participants faced different communication problems and dealt with them in a different ways. It was challenging and socially engaging.
- The idea of a physical cube to hold in hands was effective. The kids liked it a lot.
- When telling the kids about the further development with the electronic cubes, they seemed very interested in that direction.
- The modularity of the cubes worked well. The group of the kids suggested that they would love to be able to form groups with cubes and play against each other.
- They were challenged by the game mechanics and most importantly; almost everyone (save 2 or 3 testers) actually had fun.

Overall, the play test was very informative and helpful for the further development of the project. The users that participated were not of the target user group, but the test
revealed that the previously defined age group could be expanded. Since the very first steps during the board games prototypes, different aspects were prototyped separately. This relatively successful paper prototype test was the key to start working on the first integrated, prototype.

**Electronic cube prototype:**

Initially, two interactive wireless cubes were planned for this iteration. But eventually, realizing that there is no point in spending so much time on producing identical cubes, which will be refined right after to another iteration. Just one cube was made fully and a matching exposed circuit on a breadboard, which represents another cube in the network, was presented for the testing.

**Production of the cube:**

- This prototype consisted of two identical circuits: each circuit has 6 LEDs, 6 buttons (soft switches), xBee module.
- Soft switches were made from a simple fabric, aluminum tape and a thin foam layer.
- Each side had a wire soldered to the aluminum tape.
- With a huge help from Joe Saavedra, another second year MFA in Design and Technology student, two circuits of 6 soft switches turning on 6 LEDs in the same circuit were made.
The next step crucial step was to make the wireless connection between the two. After many hours and a lot of frustration it was successfully, wirelessly turning on LEDs from board to board. Next step: Sawing the cubes.

- A cardboard small cube to contain the Arduino and the breadboards was made. The soft switches were attached to the 6 different sides.
- The top layer is a soft, stuffed cube, made of a tablecloth material.

Testing:

After finishing building this electronic prototype it was tested among my peers and other students from my residents. In each testing occasion the different features of the cube were demonstrated, the concept and the further development plan were explained. The cube was handled to the tested user with the matching push buttons circuit on the breadboard. The users pressed on the different sides and squeezed the cube. While pressing the different sides of the cube most of the users were looking at the bread board to see if a matching LED lights up on the board, in the same way the users pressed the buttons on the board and flipped the cube side to side to find the matching illuminated side.

Evaluation:

This prototype work process was very challenging but as is, the accomplishment of it was very satisfying. The goals that were set for this prototype:

- Build a circuit of 6 buttons and 6 LEDs that will be wirelessly connected and responding to each other.
- Design a first iteration of the soft, vinyl cube.

Both goals were achieved. The results were pleasing. The circuit in the cube and the wireless communication both were working well. It was the first proof of the intended technology for CubeBuddy. The soft shape of the cube had nothing of the visual branding of the final idea, but its softness and size seemed to be as a successful iteration. Tested users seemed to be enjoying playing around with the cube. This iteration mostly concentrated on the technology implementation part.
MID-TERM EVALUATION AND FEEDBACK

The latest described prototype of the thesis project was the result of a very long research and iterative process. Through the first steps of the research, it became clear that there is a need for educational medical toys, and designing interactive toys for this environment and application could be extremely beneficial for patients sharing this common experience. The interviews and observation at the hospital showed lack of social interaction amongst the hospitalized children (ages 6-18), especially those enduring extended stays in the hospital. This problem is even worse for patients staying in the isolation rooms. The goal became to find a way to increase the opportunities for social communication within these children.

From this goal evolved the first thesis and original design idea: usage of play in the form of an interactive board game as a frame for collaborative play and communication. The interactive board game concept went through several different iterations. The process had an interesting flow. The mechanics of the game got more and more complex. Eventually by stepping back and reevaluating the process all aspects of the game were completely changed. From this a simplification process has started. Eventually it became so simple that it did not make any sense to continue the form of a board game.

After much consideration, eventually arrived the form and conceptual development that defined the project as a form of a social, network based, communication device and gaming platform, in shape of interactive cubes.

By looking back at the process that the project went through up until this point, it was important to go through each step of the iterative design process, and creating different prototypes. The user test created the building blocks for the future development of CubeBuddy as it for its final form.
Evaluation of the mid-term final presentation and additional feedback and ideas:

Since the project finally evolved into the latest form of interactive cubes, it seemed as getting on the right track. Any additional feedback, ideas or comments about the project were valuable and important. During the mid-term final presentation, an interesting range of comments were received. Some were supportive of the ideas that were presented, while some of the comments raised valid questions. The main concept of the project got almost unanimous support from the critiques, which validated the overall design questions and goal for the project.

The wide age range of the target user was questioned during this presentation. To answer that: the project started with much more narrow user target, but through research it appeared that in a hospital setting there is no way to ensure a certain age group of children. The ages and the numbers vary so much, that it is important to find a way to create a device suitable for all ages, or at least a broad spectrum of maturity level and development.

Another question was how this project was specifically designed for young cancer patients? That question actually had very important impact on my project following the presentation. I spent a lot of time thinking about it, and came to the conclusion that my main goal should be to create a fun device, and any “cancer” narrative for the game seemed to be forced and didn’t work as a positive aspect to the game. The enabling of distant communication, as well as the form of the device make it appropriate for a hospital setting and this user group. Specifically, the material the device is made from is easily sanitized which is absolutely necessary if any hospital would consider exposing patients to it. There are no small pieces as there would be with a standard board game, and as the cubes are completely self-contained, sanitization is very simple and maintains is inexpensive.

Another interesting point was brought by Kyle Lee, a research faculty in Parsons, The New School for Design, was that the main strength and goal of this project is being
a communication device that uses a game as a frame for that communication, and the importance of highlighting these features.

After the final presentation the project was discussed with Stefan Agamanolis, chief executive directors at Distancelab who worked and continues to develop vary distance communication projects. It was very interesting conversation and his feedback was extremely valuable. It was exciting to realize how his projects deal with similar problems as CubeBuddy. A very interesting idea that Stefan had about project, was how it might be used for a research about the influence of the increased social activity within these patients on their medical, psychological or social condition, once it has been developed and used over a period of time.

After reflection and evaluation on this entire process, came an opportunity to reframe the project to a more accurate definition and plan the next steps. At this point the thesis project was solid and clear and an integrated, working prototype needed to be developed and build. As this project got more complicated technologically, it would be necessary to find a collaborator with a programming or electronic background. Also the actual materials for the cubes had to be researched and chosen.
ADVANCED PROTOTYPES

**CubeBuddy version01 prototype:**

Implanting the previous mentioned conclusions and plans came into an advanced, integrated prototype that was developed. This prototype was what defined CubeBuddy’s final shape as it for now.

**Software development - Arduino code:**

My brother, Dan Goldberg, developed the Arduino code. During the development of CubeBuddy Dan was a third year, electronic engineering student. He lives and studies in Israel. This collaboration was not simple because of the distance, time difference and him being a student as well with his own schoolwork and deadlines. However, having very limited financial resources for this project, this collaboration seemed the only possible one. The methodology for this collaboration worked as follows: I planed the flow chart of the game, as it should be programmed and emailed sketches and charts to Dan, usually followed by Skype video chat. On his end, Dan wrote the code, and ran it through a very limited testing. He had one partially completed circuit on his own; his circuit had no XBee module and he had no other circuit to test the communication. To fully test the written program, Dan emailed it to me and I uploaded it to the two wirelessly working circuits. During the testing the success of the code and the compatibility with the requested program was checked. At times, it would be possible to show Dan the actual results using webcam through a Skype chat. Very often the troubleshooting of the code was done by back and forth emails to each other.

The process was not easy and obviously not fast enough but we were trying to get the most out of it and worked very hard to succeed. Multiple versions of the code were written but at a certain point a decision to change and simplify the interactivity was made. The reasons for this change were the technological development barriers and the need to have a working prototype as soon as possible for testing.
Interface Design – Sewing the cubes:

As the first step towards designing the interface of the cubes a research about different materials and fabrics needed to be done. During the visit to The Children's Hospital at Montefiore, Vinyl fabric appeared to be one of the preferable fabrics that are used by the hospital. The most important quality of the vinyl fabric is being easily cleanable. For this reason the search for the right fabric was among the Vinyl fabrics. Another desired quality of the fabric was it being white. The game is based on colorful illuminating LEDs so a white and clear fabric would be the best choice to show them. Different kinds of vinyl fabrics in different stores were checked. Most fabrics were very thick and blocked the LED light from illuminating through it. Another problem was the rigid surface of the fabric.

Finally, the perfectly fitting the requirements a fabric was found in at Mood Designer Fabric, in New York City. It was a white, very soft Tyvek fabric. It is pleasant to touch and might be very easily wiped or sterilized. It was not a very cheap fabric, so for this reason it was used just for the surface of the cube. After further research about the fabric it appeared as a great choice. It was already widely used by hospitals. It is a very cheap fabric when ordered from the right retailers for production purposes. Other materials were gathered for the prototype: foam, cheap cotton, white fabric for the inside parts of the cubes, invisible-white zippers.
The sewing process was planned in advance and paper templates to cut the fabric were made. Six of 7x7” squares, with an inch for the stitches on each side were cut from the Tyvek fabric. Also another six, equal squares were cut of the cheaper, white, cotton fabric. Each one of the six sides of the cube was sewn of one Tyvek fabric piece (the surface) and one simple, cotton fabric piece (the inside). Pockets were created by leaving one side of the square not sewn. The purpose of the pocket was to enable sliding in the soft switches that were made independently to the cube exterior shape. When all six pockets were done they were sewn together to one cube. Two sides were left un-sewn, to enable inserting the circuit and the switches. To close the cube two white, invisible zippers were sewn on each cube.

**Hardware development – Circuit:**

The prototype uses Arduino board with the ATmega328 microcontroller. The TLC5940NT LED driver enables to multiple the inputs and outputs of the Arduino board. XBee 802.15.4 RF module provides up to 100 feet indoor wireless communication. The prototype powered by 9-volt battery.

**Hardware Design – soft switches, integrated LEDs:**

The materials used to make the soft switches were cotton fabric, conductive fabric, conductive thread, 30 gage wires, ½ inch foam sheets and RGB LEDs. For each squared switch two 6x6” cotton fabric pieces were sewn to 2x2” conductive fabric pieces. To each conductive fabric piece, using a conductive thread, were sewn 30 gage wires,
one blue that will be connected to the Arduino input pin and the other one red that will be
cConnected to the power. Between the two sewn pieces of the cotton fabric with the
Conductive fabric was inserted a 6x6” square of foam with holes in it, a bit less than ½
Inch each. To third piece of fabric RGB LED was connected. Four wires were wrapped
On each leg of the LED. All three pieces of the fabric and the foam were sewed together
As a sandwich.

Interaction signals and game design:
In order to test CubeBuddy number of possible games were suggested. Pressing
Any of the sides will illuminate it with a random LED light. More than one side can be
Pressed at the same time. The first game option: when four sides of the cube are pressed
Simultaneously on both the cubes, a wireless connection created between those cubes.
From this point the game starts. The game played by turns. First one of the players
Presses one of the sides, while the other player can’t see where he pressed. The other
player’s task is to find where it was pressed on his own cube, which matches to the other cube. To do so, the first player verbally, using the walkie-talkies, instructs the second player how to find the right side on the cube. While the second player is trying to locate the pressed side, by the first player side, the first player is able to track his movements on the cube. After the second player succeeds the roles switch between the players. This game was not finished and not tested for its mechanics in ahead but it seemed that it would do a good use of the cube interface as a communication device and a gaming platform.

The second option: this version was an outcome of an endless troubleshooting of the code that Dan has been writing for at least two weeks. At this point of the project it was essential to test the prototype. In order to do so, it needed at least one working game on it. Therefore, it was decided to step back from the previous game, to a much more simplified game, which needed, relatively simpler code. This game was designed for testing purposes only and not to be used in the future, as a game on the CubeBuddy. Dan was able to write the code for this specific game in just few days, which allowed test the interface design of the cubes.

The third option: this version of the game is a result of a long process of simultaneous work on the interface design, hardware and software of the cubes. As it came closer to the more advanced prototyping, the game mechanics and the device design became very dependent on each other and changes within one of them cause changes within the other. At this point after long and tedious experimenting, conceptualizing and analyzing process, was decided to give up on the use of the walki-talkies. Instead of the walkie-talkies sound elements were added to the game. This game idea was a competitive, multi-player game. After the connection assembled between the cubes, the same way as it was in the previous versions, a white light would illuminate in a random side on both the cubes. The players should find the side and press on it. The first player who presses the white side causes it to illuminate on the color the player was assigned with when the cubes made the wireless connection. The goal in the game was to be the first one who presses the white side. After six rounds the player who pressed the most of
the white lights wins and both cubes will illuminate with the winning player color. The pressing actions would be accompanied by sounds.

After testing the interaction and the interface corresponds to the output/input signals, more adjustments and further development were made. This brings it to the final integrated prototype of CubeBuddy, which was used for the final testing in New-Heights Academy middle school, another Playtech event, the primary testing at The Montefiore Children's Hospital and the final thesis presentation.
FINAL PROTOTYPE

Interface:

CubeBuddy is a 6x6” soft white cube. Despite being a cube, the toy playfully suggests human characteristics through its two floppy legs yet still leaves space for imagination and personal customization via stickers and/or markers. The play is based on colorful illuminating LEDs underneath the surface fabric. For this reason using a white color for its surface is the most efficient solution. To provide it with a more playful and cheerful look colorful embroidery was added on its edges. An invisible white zipper on the bottom side of the cube provides the access to the electronics inside of it. The cover of the cube can be washed or replaced.

The material used for the surface of the cube is Tyvek. Tyvek is used for different purposes in various industries. Tyvek is well known for its use for packaging and clothing in the medical environment. It’s a very strong, hard to tear, waterproof yet breathable material. Different types of the material provide more unique qualities such as a high bacterial resistance. Using Tyvek for the surface of the cube and possibly for the inner parts suggests excellent solutions to the strict requirements of the hospital environment. It can be wiped easily, washed and sterilized using different sterilization methods.

Hardware:

The prototype uses Arduino board with the ATmega328 microcontroller. The TLC5940NT LED driver enables to multiple the inputs and outputs of the Arduino board. XBee 802.15.4 RF module provides up to 100 feet indoor wireless communication. The prototype powered by 9-volt battery.
Each side of the cube has a soft switch with augmented by three, colored LEDs. The soft switches are placed inside an inner layer in the cube. The materials used to fabricate the inside parts of the soft switches are cotton fabric, conductive fabric, conductive thread, 30 gage wires, ½ inch foam sheets and RGB LEDs. For each squared switch, two 6x6” cotton fabric pieces were sewn to 2x2” conductive fabric pieces. To each conductive fabric piece, using a conductive thread, were sewn to 30 gage wires. One blue wire is connected to the Arduino input pin and the other one red wire is connected to the power. A 6x6” square of foam with holes in it were sewn between the two pieces of the cotton fabric. Another piece of fabric were sewn to the RGB LED. A wire is connected to each leg of the LED. All three pieces of fabric and the foam are sewed together as a sandwich.
**Software:**

My brother, Dan Goldberg, developed the Arduino code (Appendix). During the development of CubeBuddy Dan was a third year, electronic engineering student. He lives and studies in Israel. This distance collaboration was enabled through Skype and emails. The code was written by Dan in Israel but was tested in the United States. This methodology created many challenges and difficulties during the development process but at the same time it was the only affordable solution. Also, this distance experience perfectly reflects the core idea of the project--distance communication.

**Interaction signals:**

CubeBuddy is a gaming platform that can be adjusted to create a variety of games and activities through its simple interface and interaction loops. Each press on one of the sides of the cube illuminates colorful lights randomly changing between red, blue, green and purple colors. Each press also produces a short beeping sound. While one cube is being pressed on one or more of its sides, a white light illuminates remotely on a corresponding side of the second cube and provokes a sound from it.

The interaction with the interface is open ended so that players can design their own experience. However, to provide a starting guide to CubeBuddy basic communication signals were established.

**Simon Says**

Simon Says is a memory game in which one player creates a sequence for the second player to repeat. CubeBuddy Simon Says is played on the cubes without any requiring any additional software. The game play starts by using the provided signals or another new signals that are decided by the players to communicate to each other the intention to play this game.

- The game starts when one of the players presses a sequence of 4 (or more) different presses on the different sides of the cube.
- The other user follows the sequence by watching the white light followed by sound, illuminating on the different sides of the cube.
- When the first user finishes the sequence the second user repeats the sequence on his cube. The first user follows the white light to check the repetition of the sequence by the second user.
- If the second user repeats correctly, the first user signals to him by pressing 3 times on the front side.
- If the second user has a mistake he signals by pressing 3 times on the backside.
- If the second user repeats correctly and gets an approving signal from the first user, he gets to make a new sequence.
- The game goes on until the users decide to stop playing.

"Hot Potato"

This modification for CubeBuddy of the Hot Potato game is part of the installed software on the cube and is an example of more complicated games that can be designed and programmed to augment the initial software

- Simultaneous pressing on the right sides of both the cubes activates the game.
- The game starts with a randomly placed white, blinking light accompanied by sound
- The players compete to locate the light and press it
- The cube of the player who presses first will show green lights on all six sides.
- The cube of the player who presses second will show red on all six sides.
- After that a new white light starts to blink on both players’ cubes.
- The game consists of up to 5 rounds.
- After 5 rounds the player who has won the most rounds is King CubeBuddy.
- To indicate the end of the game and the winner, the winning cube will show green lights and emit a special victory sound sequence.
- The losing cube will illuminate with red lights and a loser sound sequence.
- After the game is over the cubes reset to the initial state, before the game is activated once again
The rules for these basic games are provided in an accompanying booklet. In addition, the booklet provides blank templates for creating new games.
User test at the New Heights Academy

The user test took place at the New Heights Academy, on March 23, 2010. The users were 19 6th graders, ages 10-12. The total session duration was 45 min.

The prototype that was tested is an alpha version of CubeBuddy. It has a very high-end interface finishing and fully working hardware. The software development is still not at the same level as the other parts of the prototype. The test consisted of two CubeBuddy devices. Each device enabled interaction of the user by pressing on all 5 sides of the cube, getting illuminated colors and simple sound feedback on each press. Both CubeBuddies enabled wireless interaction between the two by returning illuminated white light when the other user pressed on his cube. At this point the Cubes didn't have any games installed.

The play test

At the beginning of the test CubeBuddy was presented to the class. The concept and the development process as well as an introduction to the prototyping process were introduced to the class in form of a verbal presentation. The interaction with CubeBuddy was demonstrated to the children. After the presentation they had an opportunity to ask questions.

The introduction presentation was followed by actual play and testing. Two by two, the children came to the back of the class to participate in the test, meanwhile the rest of the class were participating in another presentation by one of the other MFA Design and Technology students, who was testing his project as well.

At the beginning of each pair's playtest, the children were instructed once again in how to interact with CubeBuddy. Each user was given one device. For the most part the
children were seated separately of each other, where they couldn’t interact directly with each other and got an artificial sense of a communication from a distance.

The interaction instructions were as follows: The cubes are a communication device and a gaming platform. At this point the games are not enabled electronically. However, the basic wireless interaction is working and with the existing interactive tools the goal of the play is to start a communication between the two players and perform a few rounds of a well-known and popular memory game among the children, Simon Says. The communication is established by using defined rules of interaction with CubeBuddy. By pressing 3 times on the front side of CubeBuddy one player signals to the second player that he is interested in playing with him. To accept one player’s invitation the second player needs to press back 3 times on the front side of the cube. When one of the players presses on his cube the second player always sees it illuminated in white light accordingly on his own cube.

After the players agree to play together they will choose a game to play. Each one of the sides on the cube indicates a different game, which further will be installed by the software on the cube. To simulate the gaming option, the users used the defined games’ sides to sign each other to start a game. 3 presses on the right side of the cube by one of the player’s signals to the other that he is interested to play a Simon Says game. When the second player sees the right side illuminated with sequenced 3 white lights, he knows that player one wants to start a Simon Says game with him. By pressing a sequence of three
presses on the right side the second player signals back that he accepts the invitation to play Simon Says.

Then, the player who was the first to invite the second player for a game starts a sequence of any three random presses. The other player follows the first player by pressing on his own cube by seeing white lights illuminated on the different sides. After the first player finishes his sequence the second player repeats it on his cube. The first player follows him and checks if it is a correct order. If the second player repeats correctly the sequence the first player signals him by pressing 3 times on the front that he got it right. If that happens the second player gets to be one to perform his own sequence for the first player to follow. In case that the second player makes a mistake in following the sequence, the first player signals him by pressing 3 times on the back of the cube. In this occasion the first player is the one to perform a new sequence again.

To test more possible interactions with CubeBuddy a few pairs were seated together instead of separately. Some of the children were given the option to play with the cubes in a free form and try to establish a connection with the other child by interacting through CubeBudy. In this case the users were not instructed to play Simon Says. As a result, the play was more intuitive relaying on feedbacks from CubeBuddy. The children seemed to be adjusting pretty fast to the interface. Each pair of children got to play with CubeBuddy 3-7 minutes.

At the end of each play of the pair they had a short opportunity to express their impression of the play and ask some questions. At the end of the whole session all the children in the class were asked to fill out a survey.

Results and evaluation

At the first part of the session, during the presentation of CubeBuddy to the whole class a real and sincere interest and excitement were noticed in the children. They were very engaged and asked a lot of questions about the design process and the possible
features of CubeBuddy. Already at this point they were enthusiastic to give their opinions and suggestions for CubeBuddy. Some of the main comments/questions were:

- “Can the CubeBuddy walk?”
- “Can it talk?”
- “Can it have face? Hands?”
- “How many games does it have?”
- “The legs should have buttons.”
- “What does it do?”

During the play with CubeBuddy, most of the children seemed to get used very fast to the interface and the interaction rules. For several kids the interaction was harder and they seemed confused. Most of the tested children were familiar with the Simon Says game, and it was much easier for them to pick up this game on CubeBuddy. Just a few children were introduced for the first time to game but very shortly they learned how to play. During the observation, most of the players seemed to enjoy the form and the feel of CubbeBudy, they thought it looked comfortable and pleasant to hold, press, rotate and hug. “It’s so fluffy”, “It’s so soft”, “I want to hug it”; were repeating reactions by the children. The feedbacks on the colors were positive as well. Overall they all seemed to enjoy the play.

It was very quick to notice that in spite of the defined signals to each other and the possible game play there were many difficulties and barriers in the communication. At times some of the children looked a bit frustrated and some tried to cheat by looking to the other side to pick on the other’s player cube or to look at the other player for his reaction and facial feedback. The need for increased communication features became very obvious. Another problem that repeated during the play were technical bugs on the CubeBuddy, while sometimes the buttons got stuck or didn’t work at the press. The sound feedback was enabled just for the personal cube presses. Not having a sound feedback when the other player was pressing the bottoms made it very challenging to follow.
After the children got the opportunity to play with CubeBuddy they tended to express their excitement and kept talk about their experience. Many of them asked when will it be available to purchase and how much will it cost. As well they were interested to know how many cubes there are going to be in total.

From evaluating the surveys that the children filled out at the end and from the overall observation a number of conclusion were made for further development:

- The children approved the shape, size, colors and the material used.
- The illuminated colorful lights and sounds are feedbacks liked by the children.
- Being CubeBuddy a gaming platform and having games installed on it are desired features by the children.
- Sound feedbacks when the other player presses the buttons need to be added.
- The legs should be incorporated in the interaction with CubeBuddy.
- The children expressed interest in customizing and adding personal character adds-on to the CubeBuddy, like being able to draw on it or add stickers.
- The communication features should be improved and the walkie-talkies should be a part of CubeBuddy, as it was in some of the former prototypes. The need and the desire to have the cube talk appeared in every survey filled by the children. By adding walkie-talkies to the legs it will provide a good solution to the communication problems, give the cube an illusion of talking cube and will incorporate the legs in the interaction.
- To the question of if CubbeBudy is a toy that they see themselves playing with more than once, in all the surveys the children said yes.
- Overall the feedbacks were very good and the children expressed a lot of positive reactions to Cubebuddy.

This user test was a very important checkpoint in the design processes of CubeBuddy. It was the first time when an integrated prototype was tested. It was crucial at this point to get feedback from its potential users. The positive reactions and the feedback give an approval to the project and more specific direction for finalizing its development.
Visit at The Children's Hospital at Montefiore April 8, 2010

Presentation of CubeBuddy to Meghan D. Kelly, MS, CCLS, Director of Child Life Program & Carl Sagan Discovery Program at The Children's Hospital at Montefiore.

The latest version of CubeBuddy was presented, which consists of the hardware and interface of the prototype that was tested at the New Heights Academy, on March 23, 2010. The software was updated and developed further. This version of CubeBuddy has five sides for pressing and output, includes color and sound. Two cubes can speak to each other: when player A presses a side player B’s cube will emit a sound and flash white light. The CubeBuddy is designed for open-ended play to inspire the spontaneous invention of new games. Simon Says and Hot Potato variants were offered to play, as was described earlier in the final prototype section.

The presentation consisted of a brief pitch about the thesis and design concepts and a quick simulation of the Hot Potato game. Kelly responded with questions, feedback and general evaluation of CubeBuddy.

Kelly’s general impression of CubeBuddy was positive and her feedback was very constructive. She pointed out the use of Tyvek on the surface of the cube as a good choice. Tyvek is actually being used for different purposes in the hospital setting. It can be wiped and sterilized and at the same time is pleasant to touch. The ambiguous form of CubeBuddy is a practical design decision that frees it from a specific gender, race or ethnicity. The soft and cuddly cube is a good fit to the hospital setting and definitely can be played while lying in bed. Kelly showed a certain concern about the complexity of the interaction with the interface for the wide age group that the project targets. Another important point that was discussed was the price of a unit. The production cost was an important aspect of the design process as for the previous research and understanding the limited financial funds of hospitals. The cost of each unit at this prototyping stage is about 60-80$. The prices of the parts that are used for prototyping are very expensive. However, the real production cost will be significantly reduced.
This meeting and discussion with Kelly was very important and necessary for further development and permission for a user test with the children at the Oncology-Hematology unit.

**Play Test at The Children's Hospital at Montefiore, April 13, 2010**

The user test took place at the The Children's Hospital at Montefiore, in the playroom of the Oncology-Hematology unit. The users were ages 9-18. The total session duration was 60 minutes. The same prototype that was presented to Kelly was tested.

The playroom is located on the same floor of the Oncology-Hematology unit, has big screen windows, and allows easy access for the children on the floor. The playroom is open for specific time slots during the day while there is supervision by a Child Life Specialist. The playroom is stocked with different types of toys and games. Books and craft activities are available in the room. A Wii station is installed in the room with all the accessories for a Guitar Hero game. The Wii seems to be the center of attention in the playroom. During the play test in the playroom there were 4-6 children. However, only 3 of them were in the age range of the user target and were participating in the testing. At the beginning of the play test the children were introduced to CubeBuddy and its functionality. The interaction and the game rules were introduced and demonstrated.

The children:

- 9-year old boy who looked a bit tired and seemed fuzzy. His hand was hurting from the IV installment but he wasn’t receiving any medication through it during the play test.
- 16-year old teenage girl who was sitting on a chair in front of the table playing with decorative beads. She looked very upset and it didn’t seem like she actually made any progress with the beads. She seemed very apathetic about any activity in the room. Periodically she talked on her cell phone.
- 18-year old teenage boy who was receiving medication through the IV. In spite of being restrained by the IV pool he seemed to be very active in the
room and engaging other children with different activities. He is very friendly, outgoing and talkative.

**First play session:**

The 9-year old and the 18-year old boys were the first to play. The 18-year old boy suggested going outside of the playroom, as they were told that the game is designed to play from distant locations. The 9-year old stayed in the playroom. He seemed a bit confused and for some reason stayed standing with CubeBuddy in his hands through the whole play session. The 18-year old boy picked up the interaction with CubeBuddy very quickly and was leading the game play. The boys started playing with randomly pressing on the cube and through watching the results they began to understand how the cube works. The boys were able to communicate the initial signals of playing with the cube. They repeated three presses in a row on the face of CubeBuddy to signal and accept the play together. They were able to play one game of Hot Potato. While the 18-year old teenage was completely in control over CubeBuddy the 9-year old boy was confused and needed assistance to play. At some point he complained that his arm hurt. After this incident the 18-year old was invited to come back inside of the room and they played a bit when they were inside of the room. The interaction was mostly pressing different sides on the cube and trying to track the other player’s movements. The Hot Potato game seemed to be exciting for them although it mostly got stuck or didn’t work.

**Second play session:**

The play session was between the 16-year old teenage girl and the 18-year old teenage boy. The boy was playing for the second time while the girl was playing her first time. The teenagers were playing while they were at the same room sitting around the table. In spite of her apathetic attitude to the surroundings the boy was able to engage her in the play with the cubes and proudly shared his expertise on CubeBuddy. The girl showed very different physical interaction with the cube by the way she held it or pressed on its sides. She was very nurturing in the way she pressed on it. While they weren’t playing she was leaning on it, almost as a pillow. The boy demonstrated to the girl how to play and how the game is activated. They had two successful sessions of the Hot Potato
game. At some point they got really engaged in playing with the cubes. They thought that they still were playing the Hot Potato game but the game ended a while ago and the cubes were on their initial play state. What they were actually doing was chasing each other’s movements. Their movements got faster and faster and they were very clearly having fun with that. Just at the end they were told that they were not playing the Hot Potato game anymore and basically had invented a new game. To realize that made them laugh and they seemed to be very pleased with the fact that they just invented a game. The teenagers continued to play until a nurse distracted the girl.

Discussion and feedback from the children:

All the children were able to understand what a prototype is and what the limitations of it were. They were very patient with the technical bugs that CubeBuddy still has. The 9-year old boy was less talkative but answered questions. For the question of what he would improve in CubeBuddy, he suggested making it adjustable to different difficulty levels. He liked the different light colors on the cube and that he could play with another kid. It was difficult to get the girl to talk but her reaction was very positive and she said that she really liked the shape of the CubeBuddy and she enjoyed playing with it. The 18-year old teenager was extremely engaged and enthusiastic about the cubes and after the other two kids got tired he was still playing with the cubes. He was talking a lot, making suggestions, asking questions and taking notes. He was very excited about the opportunities in connecting CubeBuddy to the Internet and he was the one to say: “OH, it will be perfect to take to the isolation room!” He continued to make suggestions about how kids can come up with their own games for the CubeBuddy and share them online. They can upload their scores and records. He loved the colors and the fabric. Also, he made a suggestion to be able to adjust the level of the sound. He kept saying how he is excited about the idea of
CubeBuddy. At some point he felt really bad and couldn’t even keep his eyes open. That was when he stopped to play and returned to his room.

**Evaluation and conclusion:**

The children at the Oncology-Hematology hospital unit are a primary user targets of CubeBuddy. Therefore it was a very crucial play test. It was impossible to test CubeBuddy in the actual isolation room since it’s a prototype and can’t meet yet the very strict sterilization requirements of the isolation room. However, the children in the playroom are in very similar medical conditions and many of them are very familiar with being in an isolation room. Performing this user test after children outside of the hospital tested CubeBuddy, highlighted the differences and the limitations in interaction with it by the same age group but in the hospital setting. Because CubeBuddy was initially designed for the hospital setting some of its aspects have no difference or special impact on the kids outside of the hospital. But, while testing it in the hospital all these specialized qualities of the cube became very important. The cube needed to be wiped before the children could play and the nurses and staff who were in the room expressed very positive reactions to the easy way it can be cleaned. The softness and the size of the cube were other qualities that had high relevancy to the medical condition of the children.

The interaction with the interface was very simple and approachable for the 16-year old and the 18-year old in spite of their medical condition, but the 9-year old seemed to have a problem picking it up. Evaluating the results of this play test with a combination of the previous play tests it seems that the more relevant user age group would be ages 10-18 instead of 8-16.

By analyzing the observation of the play test and the following discussion with the children it seems that CubeBuddy gets very positive reactions from the children. The future development plans of CubeBuddy as the connection through the Internet, adding verbal sound communication option, adding games to CubeBuddy are strongly encouraged by the children. The approval and suggestions by the children are very crucial for CubeBuddy’s development.
Playtech April 17, 2010

Another opportunity to test CubeBuddy was available as part of the Playtech April 17, 2010 event at Parsons. The Playtech is an event when children ages 8-18 are invited to test different games that are being developed in the Design and Technology department at Parsons. The duration of the session was 2 hours.

CubeBuddies were placed on a table where users could approach them and request to play. At the beginning of each play session the players were briefed about the interaction rules and the available games—Simon Says and Hot Potato. The fact that CubeBuddy was designed specifically for the hospital setting was not stated. This play test enabled additional observation of the interaction with CubeBuddy and emphasized the affect of the hospital setting and the medical condition on the difference in play and interaction with CubeBuddy. The feedback that was provided by the testers was very similar to the feedback that was given during the previous play test at the New Heights Academy School. The users mentioned the need of a printed instructions manual to help them to learn the interaction with the interface. The volume of the sound was mentioned again. The play space was very crowded and loud and users could not hear the sounds at all during the test.

The cosines and softness of the cube draw a lot of a positive feedback from the users. At some point one of the children, an eight-year-old boy, started to punch one of the cubes really hard. Fortunately the softness and the foam layers of the cube kept the electronics inside of it without any harm. Future development to add the verbal-sound
interaction feature to CubeBuddy was presented to the children and received strong positive feedback.

Nick Fortugno, a game designer and a professor at Parsons was one of the testers. His feedback was very important and valuable for future development of CubeBuddy. Nick endorsed the look and feel of CubeBuddy. He mentioned the location of the zipper as a very good design choice, since the legs on the bottom make it clear that this is the one side not designed for digital interaction. Nick strongly encouraged the addition of the verbal voice communication to CubeBuddy. He expressed his concerns that there were too many flashing lights and emphasized the importance of the differentiation of the different colors and sound sequences.

This user test was another opportunity to reflect on the strengths and weaknesses of the product.

Final Thesis Presentation and Onezero Symposium exhibition

On April 29th through May 2nd the Onezero 2010 thesis symposium exhibition including CubeBuddy was opened to the public. A short informational video was displayed as part of the CubeBuddy installation. The video provided an overview and demonstrated how the toy works. In addition posters with pictures documenting the prototyping and user testing, were on the walls. The installation as a whole made up a giant colorful cube with fluffy feet.

During the exhibition very positive feedback was received. Visitors were hugging and cuddling CubeBuddy. Playing with it, pressing on its sides. While there were two or more users they tried to play the suggested games following the instruction in the
provided booklet with CubeBuddy. They expressed a real interest in the concept and how it works.

During the final thesis presentation the demo video was screened as part of the Power Point presentation. Following the video, the impetus, research, prototyping and testing were briefly presented to the audience. The total length of the presentation was 10 minutes. At the end of the presentation a short responds were made by two distinguished guests that were invited to the talk, Margot Duffy and Claudio Midolo. The Overall feedback that they provided was encouraging and positive. They both pointed out the successful design of the look and feel of CubeBuddy especially dealing with the hospital setting challenges. “It seems like a great comfort to have for your target audience. So, I really love that about the project, and with the restrictions that you have in terms of isolation. I think you did an amazing job of having something that is both soft but also has a functionality to it.” (M. Duffy) On the other hand, they both questioned the play interaction outputs and inputs. “The interaction with it, the inputs and outputs are very, very minimal…” (C. Midolo) The main reason for this question was that these parts of the project were not presented as much during the short time of the presentation. This is an important aspect of the project but it was secondary to the concept proof and look and feel design. However, these technical aspects still need to be developed further, with close collaboration with software and hardware engineers.
EVALUATION

CubeBuddy is a two player gaming and communication platform designed for children ages 10-18, with limited opportunities for social play and peer interaction. It focuses particularly on children who are hospitalized and enduring extended hospital stays in isolated rooms. This project is designed to address feelings of isolation and provide new opportunities for cooperative distance play within the limitations of the medical condition and hospital settings.

The goal of this project was defined as a result of research and observation of existing play and education resources in the hospital. The Oncology-Hematology pediatric unit at Children's Hospital at Montefiore was the main informative resource and user target for this project. Meghan D. Kelly, MS, CCLS, and director of Child Life Program & Carl Sagan Discovery Program at The Children's Hospital at Montefiore have been providing a constant professional guidelines and feedback throughout the research, development and design process.

The research showed that there are various medical and educational solutions in form of toys and games in the hospital setting. However, the social isolation aspect, especially when it comes to actual isolation rooms, doesn’t have that many available solutions that suggest play as form of social interaction. Because of the very strict restrictions of the isolation room the social interaction is very problematic and challenging.

Starbright Word social network for hospitalized and seriously ill children among other online social networks, and instant messaging are the most available social communication resources in hospitals. There are multiple advantages within these online options but they all require monitor-keyboard interface. Long interaction with computer monitors and plastic keyboards become tiring, uncomfortable and cumbersome particularly for patients who are laying in bed and physically weak as a result of their medical condition and treatment.
CubeBuddy suggests a cozy, soft and easy to interact interface. At this point the communication is enabled by wireless remote play but as part of its future development it will have a verbal-audio communication option. The possibilities within distance communication and remote play open opportunities to overcome the communicational challenges of the isolation room.

Through play the CubeBuddy provides a unique frame for young patients to connect to each other via colored lights and sounds. CubeBuddy is a 6×6” soft, white electronic cube with colorful trimming. Its material is Tyvek, which can be wiped clean and sterilized. Despite being a cube, the toy playfully suggests human characteristics through its two floppy legs but still leaves the space for imagination and personal customization with stickers or markers. A wireless module installed in each cube enables the communication features. Interaction with the cubes results in auditory and visual feedback through colored light and sound.

CubeBuddy in its final shape, as it for this point, went through a very long development process that involved iterative prototyping and testing. At its first stages, this project aimed to create a playful, tactile environment in form of educational, therapeutic game. The attempt was to create a remotely playable board game that besides the social communication would have educational and therapeutic aspects. However, going forward with the design process and following the requirements of the user’s medical condition and hospital settings the interface and the interaction with the game had to be significantly simplified.

The final outcome: CubeBuddy is strictly following the requiems that were established during the research. It had to be easy to clean and sterilize. The play needed to be consisted of simple motor tasks and easy to understand game rules to meet the physical condition of a seriously ill patient. As for the medical condition and constant medical treatments that the patients undergoing, they should be given the opportunity stop playing at any moment and resume the play at a later time. Also, the production cost is very important aspect that was taken into consideration while designing for a hospital
setting. The hospitals are very depended on funders and have very limited financial resources. Within all these restrictions it had to provide a fun play activity, and engage a wide range of ages, different genders and cultures.

CubeBuddy was tested within number user groups. The most important testing was the testing with the actual user group, hospitalized children at the Oncology-Hematology unit at the Montefiore Children’s Hospital. The testing outside of the hospital setting was very important to do as well. Testing CubeBuddy with children outside of the hospital highlighted the difficulties, limitations and differences of the design for the hospital setting, even if the age group is exactly the same.

CubeBuddy got very positive reactions from all the users for its concept, shape, colors and the material it’s made of. Adult audience as teachers and nurses were also very positive about it. The interaction with it showed promising results considering the relatively initial technical development at this point.

CubeBuddy successfully meets the requirements that were set within its goal. Its surface design fits the limitations of hospital settings. At this point CubeBuddy is a prototype and still can’t be used in the isolation room. But it defiantly will be possible at the later stage, within the actual production and sterile packaging.

**Next steps:**

The initial idea to enable audio-verbal communication through CubeBuddy received very strong support during the user tests. At this point the actual communication is limited to number of basic telegraphic signals. These signals communicate presence at the other end and to start different games. Enabling the audio voice communication will expand on this interaction and provide opportunities for meaningful communication. Easier communication and additional interaction tools will provide more options to play with the cube and will expand its usability, input and output signals.

Another very important development for CubeBuddy is to connect it through the Internet. Internet connection will significantly expand the communication range and will
provide opportunities for the young patients playfully to connect with their peers and siblings outside the hospital.

There are definite plans to submit CubeBuddy for grants and funding, this is how it might take these steps further in its development and make a real contribution to its user target. In addition, collaboration with organizations that already work in the field of assistive technology might be an extremely unique and important opportunity to continue to work on CubeBuddy and possibly to get involved in development of additional assistive technology projects. I’m strongly interested in the integration of play and particularly physical and tactile interfaces in hospitals, same way as CubeBuddy. The remote play suggests tremendous possibilities for development within the health care. Working on adjusting the design for hospital settings will provide unique opportunities for communication, therapy and education.

To conclude this paper, CubeBuddy is a project that suggests new opportunities for remote play and communication into the hospital setting. CubeBuddy is still a prototype but already proves itself. Its further development will allow bringing it to an actual implementation into the isolation room. It will make a real contribution by providing new opportunities for social interaction and play for the young patients. The research and development of CubeBuddy is just a start that opens another opportunities and brings more ideas for innovation and development for hospitals and heath care in general.
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APPENDIX: CubeBuddy final code, developed by Dan Goldberg


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