The Intersection of Video Games and Patient Empowerment: case study of a real world application

Craig Caldwell
University of Utah
Entertainment Arts & Engineering
Salt Lake City, UT 84112
1-801-803-8668
craig.caldwell@utah.edu

Carol Bruggers
University of Utah
Department of Pediatrics
Salt Lake City, UT 84108
1-801-588-2680
carol.bruggers@imail.org

Roger Altizer
University of Utah
Entertainment Arts and Engineering
Salt Lake City, UT 84112
1-801-581-5127
roger.altizer@utah.edu

Grzegorz Bulaj
University of Utah
Dept. of Medicinal Chemistry
Salt Lake City, UT 84112
1-801-581-4629
grzegorz.bulaj@hsc.utah.edu

Troy D'Ambrosio
University of Utah
School of Business
Salt Lake City, UT 84108
1-801-588-2680
troy.dambrosio@business.utah.edu

Robert Kessler
University of Utah
Entertainment Arts and Engineering
Salt Lake City, UT 84112
1-801-581-5127
kessler@cs.utah.edu

Brianne Christiansen
University of Utah
Entertainment Arts and Engineering
Salt Lake City, UT 84112
1-801-581-5127
bshiraki@gmail.com

ABSTRACT

Video games provide new opportunities for improving patients' quality-of-life via empowerment through physical exercise and interactive feedback. This paper presents an incentive-based video game that transforms physical exercise into mental empowerment to help fight cancer via positive metaphoric visualization. This video game technology can enhance patients' resilience via mechanisms that stimulate coupling between the brain reward systems and physical actions. While the Patient Empowerment (PE) Exercise Video Game is an example of an active-player interactive game designed for pediatric cancer patients, this concept can be applied to neurological, metabolic or cardiovascular diseases.

1. INTRODUCTION

The project was inspired by meeting a 10-year boy with a life-threatening form of brain cancer. This boy was putting extraordinary effort into fighting his disease. This observation prompted us to pursue creating an interactive videogame that could promote this concept It was observed that the *incentive spirometer* that measures how high patients can raise a ball by blowing into the device, stimulated improvement through visual feedback the device provided. This was the inspiration for empowerment interactive technologies as the boy challenged himself to raise his marks when breathing into the device. This simple tool illustrated the principles of interactive technology; direct patient participation at improving function. [1]The first challenge was to create a game design specific to pediatric cancer patients to help them visualize his/her battle against cancer? The second challenge was how to facilitate multidisciplinary collaboration among clinicians, patients, psychologists, physical

therapists, and videogame developers to get such a video game created and clinically tested.

Patient Empowerment Interactive was started in 2011. The prototype was designed and built, and a first IRB approved prospective clinical trial began in summer of 2013.

2. BACKGROUND

Commercial console game systems, coupled with commercially available activity-promoting video games (e.g. Wii, XBOX, PlayStation) are increasingly being adapted for clinical purposes. Exercise game systems (Exergaming) such as "Konami's *Dance Dance Revolution*" (Figure 1) have provided an effective interactive workout for children battling obesity [1-2]. Similarly, adults with cerebral palsy and stroke have successfully used Wii Boxing and Bowling in their treatments [3].

Figure 1, Playing *Dance Dance Revolution*

Patients dealing with chronic diseases experience a variety of challenges such as diminished physical capability and psychological swings. The Center for Disease Control and Prevention (CDC) has concluded that such co-morbidities reduce overall health. This not only affects medical treatments but also increases costs, which account for the majority of total health care expenses [4]. One such example is pediatric cancer, which is diagnosed in approximately 12,400 children and adolescents in the United States annually. The overall five-year survival rates for these patients have dramatically improved from an estimated 28% in the 1960's to over 75% currently [5]. When compared to

---

sibling and peers, children diagnosed with cancer experience not only significant health issues but also mental challenges including fear of death, altered body image and sense of vitality, life-disrupting pain, changes in social support, and repeated medical interventions [6]. Counseling as well as physical and pharmacological therapies are useful interventions for these co-morbidities. Research has revealed that children who have a wide range of coping strategies experience less stress and anxiety than those with a limited set of coping strategies [7]. The majority of these traditional approaches are externally administered.

2.1 Empowerment

Empowerment is a more recently recognized complementary approach for those affected by chronic diseases. Empowerment links individual strengths and competencies, natural helping systems and proactive behaviors. [8]. There are a variety of empowerment definitions (e.g. individuals, organizations, and communities). Empowerment in the PE Game is focused on the individual for the PE Game. This approach incorporates both psychological (e.g. self-esteem, self-efficacy) as well locus of control [9].

The PE Game builds on the concept that patients can directly apply empowerment techniques tailored to their course of treatment in addition to pharmacological treatments. Empowerment's positive effects include:

1) Developing resilience and control over one's disease;
2) Improving physical and cardiovascular de-conditioning related to the disease.
3) Improving future treatment through a clarification of the neuropeptides involved in resilience.

A significant feature of interactive technologies that favors future success is the *engagement* factor. For a patient's compliance with treatment is a major challenge for improving. Personal engagement, in contrast to taking medications, can improve compliance with other necessary treatments, which in turn can improve patient health and outcome. The question being asked: Are such interventions capable of promoting resilience and enhancing one's sense of empowerment over a given disease? An emerging strategy has come from unique applications of video game technology.

2.2 Exercise as empowerment

Usually when someone gets sick, the illness is a short-term problem resolved with a few days of rest. There is no obvious corollary for children diagnosed with cancer, who often times experience frequent or prolonged hospitalizations. Between cancer and recovery from cardiac surgery, each year approximately 349,500 (USA 2011) kids aged 4-12 face these challenges Family members and health care providers oftentimes have limited means to distract, entertain, or motivate them to get active [5].

Activity promoting video games offer increased health benefits in two distinct areas: (1) by encouraging exercise that is engaging as well as promoting beneficial physical activity, (2) and simultaneously supplying clinicians data collection and analysis tools to support evidence based clinical decisions. These two areas are fundamental to the future of serious games in health.

The challenge is that hospital facilities have been planned largely around the paradigm of patient rehabilitation through rest. This is still the case in spite of informal evidence demonstrating that exercise and activity promotes improved health in patients hospitalized for serious illness or recovery after surgery. Hospital facilities care processes, often not conducive with traditional exercise approach, and patients are often too ill to participate.

2.3 Health-promoting interactive technologies

Interactive technologies are providing new opportunities for patient engagement in their treatments. Increasing a patient's understanding of symptoms and medications stimulates improved patient disease management [10]. There are two major categories of interactive video games for health: Sedentary and Exercise (activity-promoting) video games.

2.3.1 Sedentary Games

Sedentary video games, such as *Packy & Marlon* and *Re-Mission*, focus on educating patients regarding a specific health condition by merging lessons and quizzes with puzzles and plots. The game *Packy & Marlon* targets juvenile diabetes; a diabetic patient learns to manage his/her diabetes by maintaining the protagonist's blood sugar within a healthy range through proper insulin use and diet, while playing towards the ultimate goal of saving a summer camp from the destruction of rodents [11].

Patients have shown improved patient self-efficacy, increased communication with parents regarding their disease, self-care behaviors improved, and reduced urgent doctor visits. This game is part of a series of health-care educational video games that include *Captain Novolin* (type-1 diabetes), *Rex Ronan: Experimental Surgeon* (hazards of smoking), and *Bronkie the Bronchiasaurus* (teaching children about their asthma).

Re-Mission was first released by HopeLab (2006) and designed to empower cancer patients by manipulating an on-screen microscopic robot to destroy cancer cells, while simultaneously educating patients about cancer and management of chemotherapy-related side effects. Two randomized, multi-center trials have demonstrated efficacy of *Re-Mission* in educating cancer patients [12] and in improving adherence to chemotherapy treatments [13].

In a recent study using the *Re-Mission* video game there was a noticeable difference between watching content on the screen and interactively playing the video game was apparent. Functional magnetic resonance imaging (fMRI) showed that interactivity stimulated activation of reward-related mesolimbic neural circuits. It was shown to increase dopamine in interactive game players [14]. *Re-Mission* shares a common conceptual goal to PE Interactive but stops short of incorporating the critical physical component that is so important.

2.3.2 Exercise Games

Konami's *Dance Dance Revolution* is one of the best-known exercise games recently adapted for treatment of weight problems. It increases physical activity, encourages goal setting and is self-motivating. Wii has developed a range of games that involve physical activity, including Super Swing Golf, Dragon Ball Z, and Wii Sports. Wii Fit is a specific collection of 18 mini games exercise games that utilize a Wii Balance Board Wii fit has sold over 23 million copies to date. Wii Fit has been an important tool in physical rehabilitation, by promoting strength training, aerobic exercise and balance activities [15]. This approach influenced the design of play in the PE Game.

3. GAME DESIGN

Normally game design is approached through a *deductive* process of pitch, prototype, test, refine design, and build. PE Game required an *inductive* process based on quantitative analysis that starts with field research. Parameters are set by the clinicians, theme set by patients, and game mechanics address needs, wants, and desires of both.

Grounded Theory provided the team with the research methodology that begins with data collection [16]. From the data collected, key points are identified, concepts are grouped, and categories are formed creating a reverse engineered hypothesis. This approach runs counter to the traditional model of theoretical framework at the beginning [17]. Validity is not determined in the traditional sense for Grounded Theory as it is judged by fit, relevance, workability, and modifiability [18].

- **Fit** has to do with how closely concepts fit with the incidents they are representing, and this is related to how thoroughly the constant comparison of incidents to concepts was done.
- **Relevance**. A relevant study deals with the real concern of participants, evokes "grab" (captures the attention) and is not only of academic interest.
- **Workability**. The theory works when it explains how the problem is being solved with much variation.
- **Modifiability**. A modifiable theory can be altered when new relevant data is compared to existing data.

It is never right or wrong; it is just has more or less… fit, relevant, workable, or modified.

Themes for the game came from the patients themselves; the images they had in their room were warriors, survivors, and super heroes. Next it was determined that "Party" games were the appropriate genre, with their many mini games that would fit various treatment needs. Numerous party games (e.g. Mario Party, Rayman: Raving Rabbits, Chuck E. Cheese's Party Games etc.) were purchased and deconstructed for optimum playing moments.

Five proved core mechanics (Figure 5) were chosen to incorporate into the PE mini games. All games incorporated both cooperation and competitiveness. Players can work alone or work together towards the same end goal of the game. After the basic prototype was developed the game was vetted with psychologists to make sure it would engage the patients and physical therapists were consulted about repetitive stress syndrome. The feedback often required revision. The games created were based on theory (cancer metaphors), pitch (cooperative, competitive part games), professional consultation, and then finalize the design and build the games.

3.1 Game Design Criteria

The game must be both engaging and effective in promoting patient exercise… and be compatible in a hospital setting. Specific criteria for the game includes:

1) Technology that uses a minimum amount of space,
2) Permits existing facilities to be used without change
3) Can be used by a variety of patients (i.e. ranging from bedridden to fully mobile)

To motivate pediatric patients to exercise and provide hospital care providers with important information on patient's condition required a two-prong solution: (1) Video game play that stimulates activity as well as engaging for the patient to play (2) Data and analysis system that assists health care providers in measuring and determining the patient's recovery trajectory.

3.1.1 Interactivity Specifics
1) Collection of physically engaging mini-games,
2) Run on a PlayStation3 video game console
3) Utilized the PlayStation Move Motion Controller wands (Figure 2).

Figure 2, PlayStation *Move* wand

PS3 *Move* wands were selected because the camera interface would not interfere with any other electronic equipment used in the hospital. The PlayStation Move motion controller uses an orb at the head, which glows in a full range of colors to differentiate players. The light serves as an active marker, the position of which can be tracked along an image plane by the camera. The known size of the light and spherical shape permit controller's distance from the camera to be tracked 3 dimensionally [19]. The simple sphere-based distance calculation allows the controller to operate with minimal processing latency as opposed to other camera-based control techniques on the PlayStation 3. Development of the PlayStation interface was made possible due to a donation by Sony USA of their Sony PlayStation Development Kit. This donation required significant negotiation to meet their criteria and protect Sony's Intellectual Property.

Specific game criteria includes:

1) Easy to understand,
2) Low or no violence,
3) Avoiding negative or/and death-related themes
4) Non-repetitive
5) Physically-active mini-games to raise heart rate,
6) Enthusiastic to play
7) Increase dexterity and range of motion.
8) Brief playing time for levels. (Cancer patients don't have endurance for long periods of game play)

Actual game implementation features required input from child developmental psychologists, pediatric oncologists, pediatric cardiologists, and physical therapists. Feedback included suggestions on promoting positive thought processes for pediatric aged patients, motion profiles for various case ranges (Figure 3), as well as safe levels of movement repetition to avoid exhaustion and overly repetitive movements that would be counter productive to the treatment.
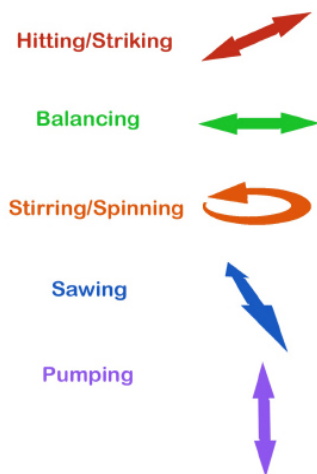

Figure 3, Motion Ranges

Due to the lack of purpose-designed exercise facilities for isolated patients during their stay, the typical hospital does not have a good way to track exercise efficacy or recovery trajectories. It is important that the game include tracking so that even those providers currently using some form of exercise treatment have a way of measuring how much it is facilitating the patient's physical capability. This information then can be used to assist in determining whether the patient can safely be discharged from the hospital sooner.

3.2 Design Elements

Players are represented by friendly characters and engage in self-empowering contests on screen, either alone or in cooperation with others (physicians, nurses, caregivers, family and friends) against the robotic, disease-related "foe" avatar - cancer.

The narrative is centered around the game's main character, Vance B. Strong an avatar for the cancer patient, who goes on vacation. Vance is a wounded super hero who will once again be powerful and strong. Heroes never really get to go on vacation, of course, and Vance ends up being charged with saving the entire town of Sandy Shore. Vance, an avatar for the cancer patient, becomes stronger as he defeats more foes. Foes include an army of robotic crabs on the beach that are undercutting the wall that he needs to build to protect the town. The crabs epitomize in-game villains, which represent cancer, and get smaller and weaker as the hero wins the day.

Everything in the game is related to the patient's experience. The mini game where Vance builds the wall to save the town was designed to be a metaphor for building up one's immune system to fight the disease. As the patient succeeds in playing the game, they can see Vance get stronger and relate. Each game is a cancer metaphor. Beach Bash mini game involves invading crabs (cancer) that need to be destroyed. (Figure 4).

Building defense wall out of bricks is a metaphor for raising your immune system. The main enemy in the game is a robotic crab (crab being the zodiac for Cancer) named B9; a pun on the word *benign*. Every mini-game in *PE Interactive* visually represents the battle against cancer. Before each game there is a mini story: Vance is resting, there is a problem, B9 comes in with a plan, Vance contributes to a better plan that solves the problem and Vance gets stronger.
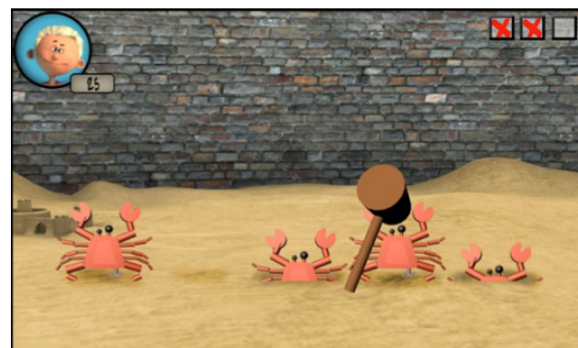

Figure 4 Screen-Shot, the Whack-a-mole level where smashing the crabs with a hammer is a metaphor for destroying cancer and building up your immunity.

Metaphor was included at every level to maximize mental connection with disease fighting. Colors were increased in saturation with vibrant graphics when depicting the character getting strong as the task is completed. The "enemy" becomes smaller and colors are de-saturated to indicate a weakening.
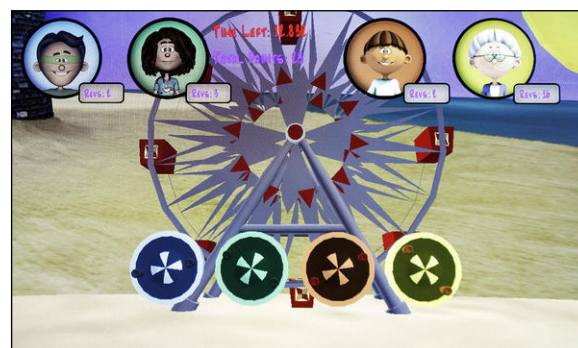

Figure 5 Screen-Shot, the Ferris Wheel challenge. The crabs have infested the mechanism and must be flung off the Ferris Wheel by spinning it faster and faster

One task is saving a Ferris wheel full of people, which require building a defensive wall around the town to protect everyone. (Figure 5) Each time the hero succeeds his persona is amplified. This unique prototype game promotes physical activity and stamina, fighting spirit and teamwork, and a sense of well-being and personal empowerment during treatment of a disease.

Each mini-game is designed to take two to three minutes to play and is individually calibrated to the child in concert with the physician. A larger task was to develop a system that is safe and effective for the child to use as both an entertainment outlet to add a little levity to a dour situation and to provide the child access to the positive feedback loop of exercise-induced chemical release within the body and brain that can help them recover from their illness faster and make the whole experience a little less awful.

3.3 Patient Feedback

Patient feedback indicated surprising results. The Fifty-Two Trash Pickup was the most broken part of the prototype but generated the most response from patients. This was because the patients were tired of being considered special and couldn't do ordinary things like pick up trash with their peers. Children at this age are currently talking about the importance of recycling, which the patient couldn't participate. This kind of feedback grounded the game.
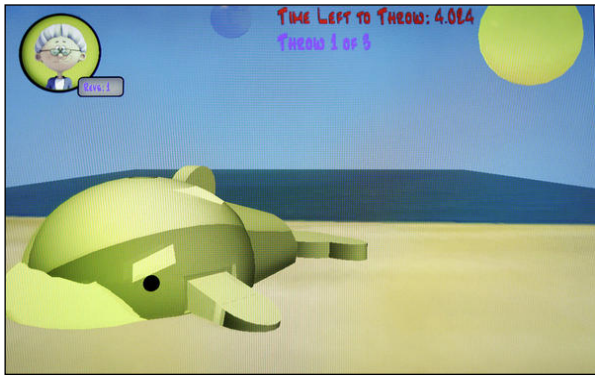
Figure 6 Screen-Shot, the Whale tossing challenge. The whale is beached. To save the whale the player must spin the wand around and around, faster and faster, to see how far they can toss the whale out to sea.

Wall Toss is drawn from the movie Hancock where he throws a whale back into the sea. This is throwing depression away. (Figure 6) Play is planned for 20 minutes several times a week.

3.4 Development

PE Interactive's development was only made possible by the collaboration between different units in close proximity at the University of Utah. The game is being developed in the new Entertainment Arts and Engineering program (eae.utah.edu). This unit inspired confidence in the medical and business collaborators due to the program's ranking in the past few years (recently ranked number one undergraduate program and number two graduate game program by the Princeton Review [March 2013]). The development process is a significant change from a customary fee for game produced transaction. All stakeholders (e.g. health professionals, business colleagues, producers, artists, and engineers) meet regularly in the Entertainment Arts and Engineering (EAE) Program to measure progress and plan the implementation.

The EAE program is able to develop this game due to the three tracks; CS/Engineering, Production, and Arts in its Master Game Studio program. The program is different in that the faculty from diverse units not only team teach but the program also incorporates a substantial proportion of industrial professionals as instructors to provide real world feedback. This is possible because there are five game studios (e.g. Disney, EA) located within two miles of the university, directly connected by the local transportation system (TRAX).

Proximity has been a critical component the success of the project. Yes, without collaboration between colleagues none of this would be possible, but it helps greatly that there is a significant entrepreneur climate at the University of Utah. This level of cooperation and participation by such a diverse group is distinct to the program. The learning environment is organized to emulate the video game industry where everyone is located in close proximity. (Figure 7) All participants have space in the same studio where they interact daily, even if they aren't following the same track.

Figure 7, Master Game Studio

The students are prepared to undertake the development of real world projects from the beginning of the program. In Semester 1, external clients are brought in to drive the requirements of the games. Structuring game projects with external clients not only more closely simulates the industry experience but also leads to increased student motivation. External clients participate by not only critiquing the initial pitches, but also have been heavily involved in provide feedback during development and on the final, prototyped version. It has been demonstrated that because the work presented was "real", it increased the quality of the final results.

3.5 The Game System

The system is being developed in three configurations (Figure 8) depending on the requirements of the hospital environment. Developed in light of existing games and research as a cross-disciplinary and non-pharmacological intervention, the prototype of the video game has been tested by pediatric cancer patients in Primary Children's Medical Center, Salt Lake City, Utah.
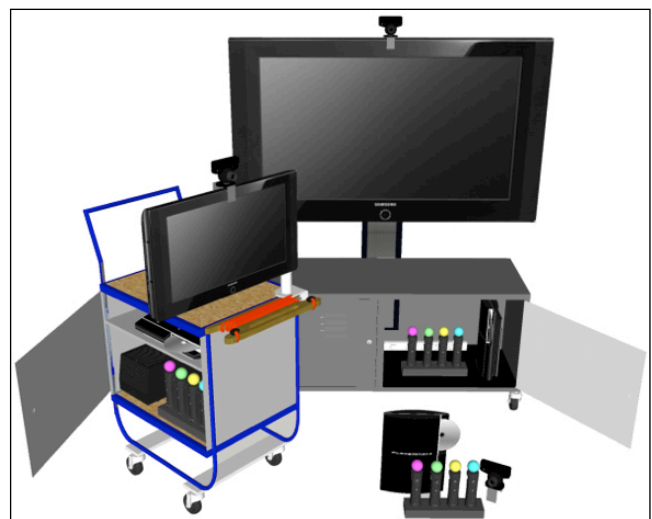

Figure 8, Multiple Formats: three different arrangements to fit a particular hospital's needs

Figure 9. Motivating, even while in bed: The flexibility of the motion tracking technology and game design allow patients with varying levels of ability and dexterity to get active. This game can be enjoyed by the patient alone, with their care providers, and alongside family members. The robust tracking ability allows kids to play from bed if they cannot stand, and monitors their progress as they recover and get stronger.

Patients uniformly expressed their enthusiasm and engagement while playing PE Interactive; they particularly responded to the capability to involve parents in the play. This was because children, unlike adults are rarely alone in the hospital. Parents with their own avatars generated involvement. Parents valued that the interactive aspect to PE Interactive that promoted physical activity. Encouraged by this positive feedback from the patients, their parents, and a variety of physicians and medical professionals, initial clinical trials are targeted at assessing PE Interactive game's safety and efficacy.
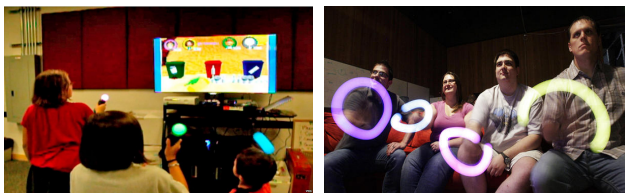

Figure 10. Players interacting with the PE game system

4. CREATING A SUSTAINABLE SYSTEM

In the health field all treatments require proof of efficacy and lack of harm before approved for release in the health system. This is an important step that is not normally encountered in the traditional video games process of market research, rapid prototyping, release to the public, and hope the game will be successful. In the health field, all treatments, mental or physical require clinical trials to establish and prove efficacy with respect to improving a patient's condition. Assessment can be done by measuring physiological and cardiovascular parameters. Efficacy with respect to empowerment/resilience is to be assessed using existing validated questionnaire tools including the Child Health Questionnaire [20, 21] the Rosenberg Self Esteem Scale [22] and the Borg Scale of Perceived Exertion [23].

The development process, whether it be a new pharmaceutical drug or the potential of curative interactive technologies have much in common. They both intend to deliver a safe and efficacious treatment that is clinically validated for a specific disease. This requires a multidisciplinary collaboration approach, involving all constituents: clinicians and their patients, psychologists, physical therapists, artists and video game developers until it is right.

An unusual challenge in developing therapeutic interactive technologies is the rapid technological advances in the gaming industry. These are in direct contrast to the lengthy clinical trials required when advancing new conventional medical therapies, and the high initial development costs.

4.1 Business plan: Patients and Hospital
The financial burden cancer treatment often places families of children with cancer under severe financial strain and unable to purchase such products as video games. To help the largest number of kids with cancer and give their families a few well-deserved moments of respite, it was decided to pursue a distribution chain that does not charge the patients for the game. Rather, the target strategy will be the hospital. The modular nature of the mini-games allows a single back end database to serve patients with a wide variety of illnesses and ages for the appropriate selection of mini-games.

4.2 Interactive Maturity
This project was initially funded by the Department of Pediatrics University of Utah School of Medicine in conjunction with the Pierre Lassonde New Development Center, and the Masters Gaming Studio. The proof of concept game and data collection system is being upgraded to fit with the clinical requirements of our medical advisors. The next phase of development of the game will be based on the feedback from current patients.

The long-term goals of interactive empowerment applications are to clinically validate the feasibility, safety and efficacy in

1) Developing resilience and empowerment over one's disease;
2) Improving disease related physical and cardiovascular de-conditioning, which in turn will likely translate into shorter hospital stays and related health care costs; and
3) Elucidating neurochemicals involved in resilience and empowerment.

5. CONCLUSION
The strategic value of PE Interactive is bridging physical exercise and mental empowerment via positive visualization. Such games as PE Interactive revealed that is more appropriate to use a more inductive process based on quantitative analysis that starts with field research as opposed to the traditional deductive process for game development. This Grounded Theory approach used parameters set by the clinicians, theme set by patients, and mechanics that focuses on positive emotions, avoids violence, and integrates safety features that minimize repetitive stress.

Distinct to the PE Interactive game was determining an interface that would be compatible with a hospital environment. The PS3 Move wand fulfilled this parameter as the controller permits the system to sense speed, direction and acceleration through optical input. Game cues (visual and auditory) provide immediate feedback and positive reinforcement. A trophy system offers a meta-game focusing on a series of achievements and collectable awards that encourage future play and the architecture also includes communication with a web server that permits the physician to monitor patient participation time and effort, and to adjust the game accordingly.

Potential benefits of PE Games specifically designed for patients of diverse ages and medical conditions including neurological, cardiovascular, pulmonary, metabolic and infectious diseases are far-reaching. A significant aspect of the interactive applications that favors their future success in health care is the "fun" factor, since unlike taking medications; playing therapeutic video games will bring genuine joy and smiles, improving compliance with other necessary treatments, which may accelerate healing.

It is important to note that the World Health Organization has endorsed patient empowerment as a fundamental method to improve health and treat disease [24]. This concept can now be further applied to individual patients via the interactive empowerment applications, such as PE Interactive. A patient will be able to directly administer his/her empowerment therapy specific to their disease in conjunction with external administered pharmacological treatments. It is the goal of the team to apply this prototype for development of activity promoting incentive based interactive games to diverse ages and diverse diseases.

PE Interactive is an integrated mini-game series, providing diverse physical exercises that accompany stories and positive visualization using metaphors for fighting cancer. Incentive-based principles can be further incorporated into other activity-promoting, interactive video game specifically designed to promote resilience in a variety of diseases. In the end, it was all due to a 10-year boy who continues to inspire us today.

6. REFERENCES

[1] Papastergiou, M., *Exploring the potential of computer and video games for health and physical education: A literature review.* Computers & Education 2008. **53**: p. 603 - 622.

[2] Biddiss, E. and J. Irwin, *Active video games to promote physical activity in children and youth: a systematic review.* Arch Pediatr Adolesc Med. **164**(7): p. 664-72.

[3] Lange, B., et al., *Development of an interactive game-based rehabilitation tool for dynamic balance training.* Top Stroke Rehabil. **17**(5): p. 345-52.

[4] CDC. Chronic diseases the power to prevent, the call to control: At a glance 2009. p. 420-423

[5] C . S . Bruggers, R . A. Altizer, R . R . Kessler, C . B. Caldwell, K . C oppersmith, L. Warner, B. Davies, W. Paterson, J. Wilcken, T. A. D'Ambrosio, M. L. German, G. R . Hanson, L. A. Gershan, J. R. Korenberg, G. Bulaj, Patient-empowerment interactive technologies. Sci. Transl. Med. 4, 152ps16 (2012)

[6] Schwartz, L. and D. Drotar, *Posttraumatic stress and related impairment in survivors of childhood cancer in early adulthood compared to healthy peers.* J Pediatr Psychol, 2006. **31**(4): p. 356-66.

[7] Zebrack, B.J., et al., Psychological outcomes in long-term survivors of childhood leukemia, Hodgkin's disease, and non-Hodgkin's lymphoma: a report from the Childhood Cancer Survivor Study. Pediatrics, 2002. **110**(1 Pt 1): p. 42-52.

[8] Rappaport, J. *Studies in empowerment: Introduction to the issue.* "Prevention in Human Services," 1984. 3, 1–7.

[9] Perkins, D. and Zimmerman, M. Empowerment theory, research and application. American Journal of Community Psychology.1995, 23 (5), p. 569-579

[10] Papastergiou, M., *Exploring the potential of computer and video games for health and physical education: A literature review.* Computers & Education 2008. **53**: p. 603 - 622.

[11] Brown, S.J., et al., Educational video game for juvenile diabetes: results of a controlled trial. Med Inform (Lond), 1997. **22**(1): p. 77-89.

[12] Beale, I.L., et al., *Improvement in cancer-related knowledge following use of a psychoeducational video game for adolescents and young adults with cancer.* J Adolesc Health, 2007. **41**(3): p. 263-70.

[13] Bavelier, D., et al., *Brains on video games.* Nat. Rev. Neurosci., 2011. **12**(12): p. 763-768.

[14] Han, D.H., I.K. Lyoo, and P.F. Renshaw, *Differential regional gray matter volumes in patients with on-line game addiction and professional gamers.* J Psychiatr Res. **46**(4): p. 507-15.

[15] Kato, P. M., Cole, S. W., Bradlyn, A. S., Pollock, B. H., *A video game improves behavioral outcomes in adolescents and young adults with cancer: A randomized trial.* Pediatrics122, e305–e317 (2008).

[16] Patricia Yancey Martin & Barry A. Turner, "Grounded Theory and Organizational Research," *The Journal of Applied Behavioral Science*, vol. 22, no. 2 (1986), 141..

[17] G. Allan, "A critique of using grounded theory as a research method," *Electronic Journal of Business Research Methods*, vol. 2, no. 1 (2003) pp. 1-10.

[18] Glaser, B. (1965). The Constant Comparative Method of Qualitative Analysis. Social Problems, 12(4), 445, 436.

[19] Kumar, Mathew (16 July 2009). "Develop 2009: SCEE's Hirani Reveals PS Eye Facial Recognition, Motion Controller Details". *Gamasutra*. Think Services. Retrieved 17 July 2009. "The sphere is what the camera is tracking, in full RGB — it tracks X and Y, and Z is deduced from the area of the sphere"

[20] Kato, P. M., Cole, S. W., Bradlyn, A. S., Pollock, B. H., *A video game improves behavioral outcomes in adolescents and young adults with cancer: A randomized trial.* Pediatrics122, e305–e317 (2008).

[21] Cole, S.W., D.J. Yoo, and B. Knutson, *Interactivity and Reward-Related Neural Activation during a Serious Videogame.* PLoS One. **7**(3): p. e33909.

[22] Bavelier, D., et al., *Brains on video games.* Nat. Rev. Neurosci., 2011. **12**(12): p. 763-768.

[23] Han, D.H., I.K. Lyoo, and P.F. Renshaw, *Differential regional gray matter volumes in patients with on-line game addiction and professional gamers.* J Psychiatr Res. **46**(4): p. 507-15.

[24] N. Wallerstein, "What is the evidence on effectiveness for empowerment to improve health?" (World Health Organization, 2006).