# Power Defense: A Video Game for Improving Diabetes Numeracy

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***Abstract*—Adolescents with T1D often have poor control of their disease. With the knowledge that the current generation appreciates and learns more from interactive approaches to teaching, we have developed *Power Defense*, a highly interactive video game aimed at improving one particular skill associated with managing diabetes – numeracy. Diabetes-related numeracy encompasses the ability to understand and interpret results and then appropriately apply the results to the management of diabetes. Power Defense employs the principals of experiential learning and includes both implicit and explicit methods for teaching the player the necessary diabetes numeracy skills.**

## I. Introduction

Type 1 diabetes (T1D) is a chronic medical condition that is usually diagnosed in childhood and it has no cure. Children and teens with T1D need to engage in numerous tasks on a daily basis to keep their blood sugars well controlled in order to prevent serious short- and long-term complications associated with high blood sugar levels including blindness, heart disease, and kidney problems. They need to measure their blood sugar levels at least four times daily and require insulin injections each time they eat. Diabetes-related numeracy is the ability to understand and interpret results and then appropriately apply the results to the management of diabetes.

In adult studies, low numeracy skills has been shown to be an independent factor in predicting poor control of diabetes and worse long term outcomes. The problems are further compounded with children and adolescents who typically resist any behavioral restrictions leading to difficulties in diabetes self-management [1]. Furthermore, management of diabetes and diabetes numeracy in particular, is typically conveyed to children and adolescents using "traditional teaching methods" (e.g., pamphlets, books, etc.). However, traditional teaching-and-learning environments are often quoted by children and adolescents (i.e., the *millennial* generation) as "boring" and they do not address the unique learning needs of this generation who prefer to be actively involved in the teaching process [2]. This high level of interactivity that millennials seek is not easily captured in traditional learning environments. However, the more recent use of simulations through virtual reality and videogames have been noted as a highly effective means of promoting interactivity and active learning [3].

Given the issues associated with educating adolescents with T1D about diabetes numeracy and self-management, and the potential benefits inherent to video games, we have created a developmentally appropriate interactive, and engaging video game, Power Defense, aimed at improving numeracy in adolescents with T1D. We will be evaluating the impact of this video game on numeracy skills and health outcomes in this population.

## II. The Power Defense Game

### A. Overview

Power Defense is based on the popular tower defense subgenre of *real-time strategy* games. Tower defense games offer simple game-play mechanics, they are fun and challenging and this has led to a large number of casual tower defense gamers [4]. In a tower defense game, the player "buys" and "strategically" places defensive towers throughout their area (typically a maze). Towers fire automatically upon approaching enemies and for each enemy a tower destroys the player earns points. If enough enemies are destroyed, the player wins the round and accumulates further points. However, if the enemies reach the end of the player's area, the enemy wins the round. The player can use the earned points to "purchase" further towers or upgrade existing ones [4].

In Power Defense, the player is given control of a reactor-based power base station (represents the person with T1D) that stores energy (represents "blood sugar level") and it is their responsibility to maintain this power station by balancing the amount of energy allowed into it. Players are provided with various tools at their disposal to do so, including four types of towers, "real-time coolant" (represents short acting insulin), and "daily super coolant" (represents long acting insulin). The station has a power output meter (represents "blood sugar level"), which must be kept at the optimal level between four and seven thousand units. During an "attack wave", energy entities (represent food) try and reach the base station. The goal is for the player to survive as many waves of energy attacks as possible, while keeping the base station's power output level within the acceptable range. Power is obtained

from the advancing energy entities; the power of any energy that reaches the base station is added to the base station's power level. The player positions their available towers around their base station to control the number of energy entities that actually reach the base station. The challenge is to place an appropriate number of towers, at the appropriate locations to ensure the base station power level is maintained within the optimal range.

If the base station power level becomes too high it will overload, and must be "shut down for repairs". If power levels are too low, the base station shuts down and must be restarted. The base station gradually loses energy over time, and must have energy coming into it to maintain its level. Towers drain the power output level. To maintain the station within its optimal output range, the player is given "coolant" to inject into the base station reactor if the output level is too high. Calculations for the amount of coolant to inject or the amount of "energy" to let in must be performed in real time similar to calculations performed by patients with diabetes for managing their blood sugar levels. If the output level is dangerously low the player can use a "Jumpstart" which offers a rapid energy boost to the base station. When the power level falls below a pre-set threshold, the game play area starts to blur, and this blurring effect increases as the level keeps dropping. This is analogous to vision changes experienced by patients when their blood sugar is low. Should the base station power level go below one thousand five-hundred, or go above fifteen-thousand then the player will have to re-start the level. The score for each level is based on how much time the player was able to maintain the energy level of the base station within optimal range. A screenshot illustrating a sample game-level is provided in Figure 1 while a sample game-play video demonstration is available from the following URL:

http://www.youtube.com/watch?v=iKUSfBRv_JI

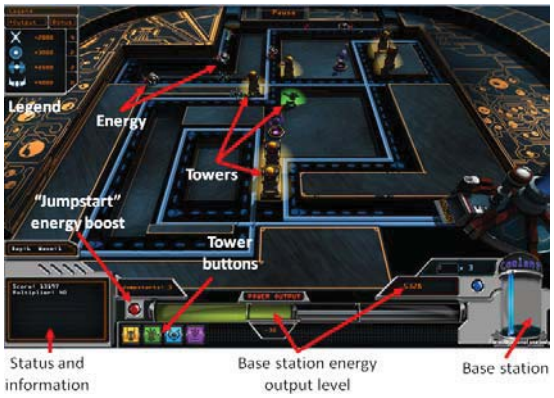


Fig. 1. Game-play screenshot.

In Power Defense, the relevant diabetes numeracy skills are imparted to the player is done so primarily *implicitly*. To enhance transfer of knowledge and skills to real-life diabetes management we also incorporate *explicit* methods of learning in the form of a "game within a game"; at certain points in the game, depending on specific user actions, the player is presented with diabetes-specific questions which if answered correctly, are awarded accordingly. Technical Details

Power Defense was developed using the Unity Pro game development tool. Autodesk Maya and Autodesk Mudbox were used to create the 3D models and animations. The game tracks various statistics for each player including: time to complete a level, number of times a level was replayed, and the number of questions answered correctly.

## DISCUSSION

Through a detailed and step wise approach we have successfully developed an innovative video game that addresses diabetes related numeracy. The game both implicitly and explicitly addresses core elements of diabetes numeracy skills. The game is interactive and appealing to adolescents, and employs various educational strategies to enhance learning and transfer of knowledge and skills to actual diabetes self-management.

Video games are popular and should be explored as a method for enhancing patient diabetes education. The development of an educational video game must be based on input from experts in the field of diabetes, education, and technology development and most importantly must be based on the learning needs and desires of the target population.

We have successfully tested the usability of the game (alpha testing) on a small subset of our target population (adolescents with T1D). We have subsequently recently begun testing the effectiveness of Power Defense with a pre-post intervention study (approved by the Hospital for Sick Children Research Ethics Board). Participants (adolescents with T1D), have played Power Defense on three separate occasions within a short period of time and then return after 1 month to play the game a final time. Numeracy skills, quality of life, and A1C levels (a blood test that measures average blood sugar control) are measured pre and post video game intervention.

Power Defense is unique as it implicitly and explicitly educates patients, through a video game, skills that they need to manage their chronic illness. The use of video games in health care and patient education is limited. The results of our study will help inform our current education practices for adolescents with type 1 diabetes.

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