Published in final edited form as:

Simul Gaming. 2016 August ; 47(4): 490–516. doi:10.1177/1046878116633331.

An educational video game for nutrition of young people: Theory and design

Tracey Ledoux¹, Melissa Griffith², Debbe Thompson², Nga Nguyen³, Kathy Watson⁴, Janice Baranowski², Richard Buday⁵, Dina Abdelsamad⁶, and Tom Baranowski²

¹University of Houston, TX, USA

²Baylor College of Medicine, Houston, TX, USA

³University of Texas MD Anderson Cancer Center, Houston, TX, USA

⁴Centers for Disease Control and Prevention, Atlanta, GA, USA

⁵Archimage, Inc., Houston, TX, USA

⁶Johns Hopkins University, Baltimore, MD, USA

Abstract

Background—Playing *Escape from DIAB* (DIAB) and *Nanoswarm* (NANO), epic video game adventures, increased fruit and vegetable consumption among a multi-ethnic sample of 10–12 year old children during pilot testing. Key elements of both games were educational mini-games embedded in the overall game that promoted knowledge acquisition regarding diet, physical activity and energy balance. 95–100% of participants demonstrated mastery of these mini-games suggesting knowledge acquisition.

Aim—This article describes the process of designing and developing the educational mini-games. A secondary purpose was to explore the experience of children while playing the games.

Method—The educational games were based on Social Cognitive and Mastery Learning Theories. A multidisciplinary team of behavioral nutrition, PA, and video game experts designed, developed, and tested the mini-games.

Results—Alpha testing revealed children generally liked the mini-games and found them to be reasonably challenging. Process evaluation data from pilot testing revealed almost all participants completed nearly all educational mini-games in a reasonable amount of time suggesting feasibility of this approach.

Corresponding Author: Tracey Ledoux, Department of Health and Human Performance, University of Houston 3855 Holman Street, Houston, TX 77204-6015, USA, TAl Ledoux@uh.edu.

The contents of this publication do not necessarily reflect the views or policies of the USDA, nor does mention of trade names, commercial products, or organizations imply endorsement from the U.S. government.

Author Contributions

All authors contributed to this article in content and in form. TL led the generation of the manuscript and managed the submission and revision process. DT, JB, TB, and RB wrote pieces of the manuscript directly. KW and NN did the statistical analysis and constructed tables to present the data. TB, JB, RB, and DT designed the overall study. TB, MG and DT conceptualized the goals of this manuscript. MG and DA conducted the study. All authors contributed to the editing process.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the authorship and/or publication of this article.

Conclusions—Future research should continue to explore the use of video games in educating children to achieve healthy behavior changes.

Keywords

behavioral nutrition; challenge; debriefing; design; diet; energy balance; experience; game design; health; healthy behavior; intervention design; knowledge; mastery learning; mini-game; obesity; physical activity; social cognitive theory; Type II Diabetes; video game

Obesity is related to Type II diabetes among youth (Franks et al., 2007; Hussain, Claussen, Ramachandran, & Williams, 2007; Quarry-Horn, Evans, & Kerrigan, 2003). Obesity involves storage of excess calories as adipose tissue and is the result of positive energy balance (EB) (Das, 2010; Krebs et al., 2007). Public health interventions are needed to reduce and prevent obesity and type II Diabetes among youth.

Participation rates in many public health programs are poor, possibly because few programs are fun. Commercial video games on the other hand are usually fun, but infrequently aimed at positive health behavior changes. Because youth play video games several hours per week (Roberts et al., 2005), the research and development team decided to apply sound intervention development strategies (i.e., behavioral theory and intervention design theory and research) to developing a serious video game for preventing type II Diabetes in youth.

Escape from DIAB (DIAB) and *Nanoswarm: Invasion from Inner space* (NANO) are epic video games aimed at lowering risk of type II Diabetes among 10–12 year old multiethnic youth by promoting increased fruit, vegetable, and water consumption and physical activity (PA) (Baranowski, Baranowski, Thompson, Buday, et al., 2011). Playing DIAB and NANO increased fruit and vegetable consumption by two thirds of a serving (Baranowski, Baranowski, Thompson, Buday, et al., 2011). Results of the randomized control trial and description of DIAB and NANO have been previously published (Baranowski, Baranowski, Thompson, Buday, et al., 2011; Thompson, Baranowski, Buday, et al., 2010). Briefly, the concepts and plot for DIAB and NANO were informed by survey and focus group data from youth (Baranowski, Baranowski, Thompson, Buday, et al., 2011). Microsoft Windows XP was the operating system. In addition to fun mini-games, goal setting tasks, and brief cut scenes to deliver the plot, a major behavior change strategy involved educational EB mini-games. Mini-games are short (1–15 minutes) challenges with a specific goal.

Enhancing EB knowledge was a behavior change strategy in DIAB and NANO because knowledge about EB, PA, and nutrition has been related to greater PA among adolescents (Nelson, Lytle, & Pasch, 2009), home food, media, and PA equipment availability (Slater, Sirard, Laska, Pereira, & Lytle, 2011), and healthier diet among children (Gonzales, Marshall, Heimendinger, Crane, & Neal, 2002; Matvienko, 2007). Also, the average youth has inadequate practical knowledge of EB (Nelson et al., 2009). EB knowledge requires comprehension of practical nutrition (energy intake) and PA (energy expenditure) knowledge. In DIAB and NANO, 95–100% of the participants mastered the educational mini-games suggesting most participants learned basic EB concepts. The purpose of this article is to describe the theoretical, scientific, and practical procedures of designing and developing the educational components of DIAB and NANO, which were effective at

increasing fruit and vegetable consumption in children(Baranowski, Baranowski, Thompson, Buday, et al., 2011). A secondary purpose was to ensure that the educational mini-games were fun, sufficiently challenging, and engaging. This will provide researchers a template for health game design for youth.

Methods

DIAB and NANO Description

DIAB and NANO contain nine episodes each. Each episode contains educational mini-games on PA or nutrition and EB, an entertaining mini game, and goal setting tasks. Episodes begin and end with a cut scene, which delivers the plot and builds suspense. Following the first cut scene is a review of goals, and preceding the last cut scene is the goal setting task. The educational and fun mini-games are in counterbalanced order with no specific transitions between them. A more detailed description of DIAB and NANO has been published (Baranowski, Baranowski, Thompson, Buday, et al., 2011; Thompson, Baranowski, Buday, et al., 2010).

Theory

Overall DIAB and NANO were predicated on multiple theories including self-determination, transportation, and elaboration likelihood theories (Baranowski, Baranowski, Thompson, & Buday, 2011; Baranowski, Baranowski, Thompson, Buday, et al., 2011; Thompson, Baranowski, Buday, et al., 2010). The behavior change strategies of the educational mini-games were based on Social Cognitive Theory (SCT) and Mastery Learning Theory informed the educational strategy (Baranowski, Baranowski, Thompson, & Buday, 2011; Bloom, 1968).

According to SCT, behaviors are the result of an interaction between the environment and individual or personal factors (Bandura, 1986). SCT posits that behavior change is mediated in part by self-regulatory strategies (e.g., goal setting) to initiate more desirable behaviors given environmental conditions. Per SCT, behavior change also requires self-efficacy (perceived ability to successfully engage in new behaviors) (Bandura, 2004). The goal of the educational mini-games was to provide information instrumental to formulating behavior change goals. For example, youth needed to understand what foods were considered to be fruits to be able to set appropriate goals around increasing fruit consumption. In addition, the concepts grew increasingly complex as the games progressed to increase self-efficacy for practical EB activities. For example, early mini-games involved identifying healthy sources of fruit and vegetables and later mini-games involved balancing energy intake and expenditure for an entire day by selecting meals and activities for their daily schedule.

Mastery learning, a method of teaching, involves instruction followed by mastery testing (Bloom, 1968). Failing a mastery test results in further instruction followed by more mastery testing until the minimum criterion for mastery is achieved (Bloom, 1968). Mastery learning techniques in the classroom have improved student knowledge of physics (Wambugu & Changeiywo, 2008) and computer science (LeJeune, 2010). In the field, mastery learning techniques have improved medical student clinical skills (Barsuk et al., 2012; Cohen et al.,

2013; McGaghie, Issenberg, Cohen, Barsuk, & Wayne, 2011). Despite its effectiveness, mastery learning is not commonly used because variations in time to complete lessons and the need for individualized instruction make it difficult to incorporate into a traditional classroom setting (Cook, Brydges, Zendejas, Hamstra, & Hatala, 2013) (Bloom, 1968). Video games can provide tailored instruction, individualized corrective feedback, and assessment efficiently, and research shows mastery learning strategies in video games have improved math knowledge (Lin et al., 2013). In DIAB and NANO, players could not advance to the next game or activity without mastering the current mini-game, and mastery of each mini-game required players to demonstrate they had acquired certain knowledge by applying it to meet the objectives of the game.

Content of knowledge mini-games

DIAB (Tables 1, 2, & 3) and NANO (Tables 4, 5, & 6) each have nine episodes (Baranowski, Baranowski, Thompson, Buday, et al., 2011), containing either a nutrition (Tables 2 & 5) or PA educational mini-game (Tables 3 & 6) and an EB knowledge mini-game (Tables 1 & 4). Nutrition lessons included instrumental information for self-regulation such as identifying:

- healthy fruit and vegetables (e.g., Figure 1 and 2);
- appropriate portion sizes; and
- number of recommended daily servings.

In DIAB (Table 2), players discriminated healthy from unhealthy fruit and vegetables choices in early episodes and then in later episodes recognized correct portion sizes of fruit and vegetables. In NANO (Table 5), players continued these lessons; however, the sessions became more complex to help players build self-efficacy toward understanding EB concepts. In early episodes players discriminated healthy from unhealthy desserts, side dishes and drinks (e.g., Figures 1 and 2). In later episodes they identified the health value of foods based on nutrition fact labels. PA lessons included learning:

- differences between strength and non-strength aerobic activities;
- recommended amounts of daily PA and physical inactivity;
- amounts of energy expended in various activities.

In DIAB (Table 3), players identified potential home-based physical activities and discriminated between types of PA. In NANO, (Table 6) lessons became more complex like overcoming barriers to exercise and planning a day's schedule to include 60 minutes of PA. Recommendations and estimated energy expenditure were tailored to player's weight and age, which players provided during profile set up.

For each educational mini-game, players only advanced to the next game when the minimum criterion was met (see Tables 1–6 for each criterion) indicating mastery and knowledge acquisition. Players had unlimited opportunity to play the educational mini-games, but only upon demonstrating knowledge/mastery of the concept could the player advance. For the untimed mini-games, players achieved mastery of the game through trial and error with ongoing progress feedback (See Table 1; Figure 1). When players were

unsuccessful, further instruction and explanation were provided. For example, in the *What counts as a fruit?* mini-game in DIAB, an incorrect fruit selection results in a big red *X* display, and at the end of the game (successful or not) all correct fruit choices were displayed on the screen. Also, the fun/enjoyment of playing the mini-game ensured the player's persistence across repeat failures, until the player succeeded. Failure was acceptable within the context of a mini-game, as long as the experience was otherwise enjoyable. Time to completion varied, but successful completion was deemed to demonstrate acquisition of core EB knowledge concepts.

Debriefing—Debriefing is the process by which learners process their thoughts and feelings about the game playing experience (Crookall, 2010; Peters & Vissers, 2004). Crookall (2010) suggested debriefing is critical to the learning process because it allows players to translate the knowledge gained during game play to real life applications. There are a variety of methods for debriefing including group discussion, written response to open-ended questions, or built in features to the game (Peters & Vissers, 2004). In DIAB and NANO, the primary methods for debriefing were goal-setting tasks. At the end of each of the 18-episodes, a character prompted players to identify a behavior change goal related to the content of the completed educational mini-games and then to outline a plan for achieving the behavior change. The game character coached players through setting realistic and achievable goals, determining facilitators and barriers, determining ways to overcome barriers, and outlining logistics for implementing the behavior. Players were then restricted (via internal feature of the video games) from accessing the next episode of the game for a day to allow time for the implementation of their goals. At the beginning of the subsequent session, a character asked players the extent to which they were successful in achieving their behavior change goal. If 100% successful, players were congratulated. If players were less successful, they were led through a series of questions to identify barriers that prevented them from achieving their goals and then engaged in problem solving to help them identify ways to overcome the barriers if encountered again. These goal setting and review tasks were built into the game for the purpose of helping players translate what they learned in the educational mini-games to their lives (Thompson, Baranowski, & Buday, 2010).

Procedures

Nutrition and PA experts worked with a game development company (Archimage Inc.) to create DIAB and NANO. Alpha testing of DIAB and NANO was conducted to determine usability. Due to funding and time constraints, alpha testing of the educational mini-games was limited to observation and a short debriefing. Revisions to the games were made based on the results of the Alpha and Beta testing, followed by a pilot test. Process variables were tracked to assess perceptions of the game play experience among children.

Game design—Researchers with expertise in nutrition, behavioral science, obesity prevention, and exercise physiology provided Archimage with goals, educational mini-game descriptions (the themes, challenges, and activities), learning objectives, and equations for calculating energy requirements and calories expended. Energy intake requirements were estimated using standard equations assuming a low level of activity, and incorporating child gender, age and weight (Rodriguez et al., 2002; Schofield, 1985). The energy content of

foods came from USDA/MyPyramid 2005 National Dietary Guidelines (USDA, 2005). Player energy expenditure was tailored to player's weight and age (Ainsworth et al., 2000; Harrell et al., 2003). The game developers used their expertise to create the educational mini-games using the TORQUE GAME ENGINE by Garage Games, Las Vegas, Nevada. Software used to create game assets (art used in activities) included AUTODESK'S 3D STUDIO (San Rafael, CA) and ADOBE SYSTEMS' PHOTOSHOP AND ILLUSTRATOR (Mountain View, CA).

Alpha Testing—Alpha testing is an iterative process of testing and refining software to meet users' needs (Serrano & Anderson, 2004; Stinson et al., 2006; Vandelandotte & De Bourdeaudhuij, 2003). Alpha testing of the educational mini-games was conducted among ten children (six females and four males) ages 9–12. The sample included three African American, two Hispanic American, four Euro-American children, and one Asian American child. Alpha testing involved three methods: observations of children playing the games; one-on-one interviews; and written survey. Triangulation (i.e., using multiple methods of data collection) maximized the likelihood that issues limiting usability would be revealed. Observers rated the children on attention, difficulty, frustration, boredom, engagement, and calmness with a measure developed for this study. Observers were trained on this measure to ensure consistent understanding of each concept across observers. In interviews (script developed for this study), participants provided self-report responses via Likert scale ratings of difficulty (*way too hard, a little too hard, just right, a little too easy, and way too easy*), fun (*not fun, a little fun, a lot of fun*), and satisfaction with length (*way too short, a little too short, just right, a little too long, way too long*) of each mini-game. In addition, participants were asked to indicate overall mini-game liking by providing an overall grade using the common school-based grading scale (e.g., 1–100 scale) with 80% representing a B-, the criterion of *passing* on likeability. This likeability question, score, and criterion were developed for this study. Revisions to the games were made based on Alpha testing results (See Results below).

Pilot Study Process Outcomes—A detailed description of the pilot study has been published (Baranowski, Baranowski, Thompson, Buday, et al., 2011). Briefly, DIAB and NANO were pilot tested among a community sample of 93 multiethnic boys and girls ages ten to 12 with baseline BMI between the 50 and 95th percentiles. Time to complete each game and number of attempts to complete each game were tracked by the computer program. Adverse events such as induction of an eating disorder were tracked as well.

Results

Likeability ratings for all nutrition and PA mini-games exceeded the passing criterion (scores ranged from 84–94.5). Each mini-game was at least *a little fun* with the *What's an Aerobic Activity?* mini-game rated as *a lot of fun*. During interviews children described the games as *good, fun, and cool* except *Objects to Exercise with Inside the Home* and *Portion Size of a Fruit* mini-games which they reported were *hard* and *confusing*. Children rated most games moderate in difficulty level, which was consistent with observation notes. The children seemed engaged and calm without excessive fidgeting, which indicated engagement.

Children rated the length of the games as *just right* except for *Decreasing Physical Inactivity* which was rated as *a little too short*. During alpha testing *Decreasing Physical Inactivity* took an average of one minute to complete, but during pilot testing it took slightly over two minutes, which was on the lower end of game completion times. No changes in this game were made.

The most common problem in the DIAB educational mini-games was children completed some game objectives without understanding the lesson. For example, one observer noted a child playing the *Activity Balance* mini-game (Table 1), "...didn't realize the purpose of the game but knew to collect the coins." Despite this, children tended to grade the DIAB educational mini games with an *A* (90–100) or a *B* (80–89). The main problems of the NANO educational mini-games were unclear instructions and malfunctioning video game pad controller. Participants said the NANO EB mini-games were at least *a little fun* and between *too easy* and *too difficult* with one participant claiming, *Loved that game!* Changes in instructions and mechanics were made before pilot testing.

Pilot study data from DIAB showed there were no adverse events from playing the games. Also, girls took longer and had more attempts to complete games than boys, but in NANO boys finished faster with fewer attempts on some games while girls finished faster with fewer attempts on other games. The time to complete educational mini-games increased across games. See Tables 7 and 8.

Discussion

DIAB and NANO improved dietary intake of players (Baranowski, Baranowski, Thompson, Buday, et al., 2011). Educational mini-games to teach EB concepts were important features of the game and were based on SCT and Mastery Learning Theory. While it is possible some players simply got better at playing some of the games without really mastering the concepts, most players achieved the goals of the educational mini-games suggesting the average player had greater EB knowledge by the end. The purpose of this paper was to describe the process for developing the educational components of this video game intervention. Development involved 1) collaborations between experts in child obesity intervention design and software developers, 2) alpha testing and debriefing, 3) revision, and 4) pilot testing.

Video games have promise for promoting positive health behaviors and health knowledge (Primack et al., 2012). Video games have improved Diabetes self-management behaviors (Brown et al., 1997) and diet (Baranowski, Baranowski, Thompson, Buday, et al., 2011; Panic, Cauberghe, & De Pelsmacker, 2014) among youth. Video games have increased youth knowledge about stroke symptoms (Williams, Hecht, DeSorbo, Huq, & Noble, 2014), nutrition (Banos, Cebolla, Oliver, Alcaniz, & Botella, 2013; Baranowski et al., 2003; Peng, 2009; Thompson et al., 2009; Turnin et al., 2001), fire safety (Morrongiello, Schwebel, Bell, Stewart, & Davis, 2012), asthma (Nabors, Kockritz, Ludke, & Bernstein, 2012), cancer medication management (Kato, Cole, Bradlyn, & Pollock, 2008), PA (Jago et al., 2006a), and Diabetes (DeShazo, Harris, & Pratt, 2010). Some video game interventions simultaneously improved knowledge and health behaviors (Morrongiello et al., 2012), but

future research should test whether knowledge mediates behavior changes resulting in video game interventions. To this end, validated measures of health knowledge are needed.

Among those games with nutrition knowledge components, lessons were similar to those of DIAB and NANO, e.g., learning to recognize “healthy” foods (Baranowski et al., 2003; Thompson et al., 2009; Turnin et al., 2001), decipher food groups (Baranowski et al., 2003; Thompson et al., 2009; Turnin et al., 2001), identify nutrient composition of types of foods (Banos et al., 2013; Turnin et al., 2001), identify appropriate portion sizes (Banos et al., 2013; Baranowski et al., 2003; Thompson et al., 2009), and recall desired servings per day (Banos et al., 2013; Baranowski et al., 2003). Among those games with PA knowledge components, lessons were similar to those of DIAB and NANO, e.g., learning to identify types and recommended durations of PA (Jago et al., 2006b). DIAB and NANO were the first video games for children that included mini-game components to enhance advanced EB knowledge.

DIAB and NANO are two of the first video game interventions to use mastery learning to impart knowledge, but most researchers do not report details describing educational components of video games (Baranowski et al., 2003; Jago et al., 2006b; Kato & Beale, 2006; Turnin et al., 2001). Other video game interventions reported using video simulations (Bartholomew et al., 2000), reinforcement (Bartholomew et al., 2000), modeling (Bartholomew et al., 2000), quizzes (Banos et al., 2013), or text boxes (McPherson, Glazebrook, Forster, James, & Smyth, 2006) to teach core concepts. Most studies did not report criterion goals of games (Banos et al., 2013; Baranowski et al., 2003; Bartholomew et al., 2000; Jago et al., 2006b; Kato & Beale, 2006; Thompson et al., 2009; Turnin et al., 2001). Future studies should develop educational games based on learning theories and report details to advance the field.

Important aspects of developing the educational mini-games in DIAB and NANO were alpha testing and process evaluation. A secondary purpose of this article was to explore the experience of children while playing the games. Alpha testing revealed the educational mini-games were of acceptable difficulty and length, and the few problems that were detected were easily corrected with revisions in instructions or technical solutions. Process evaluation descriptive findings revealed that males completed DIAB games faster than girls but that these differences diminished in NANO. These results could be related to baseline EB knowledge, gaming ability, skill, or interest. Previous research has shown boys spend more time playing video games than girls (Fairclough, Boddy, Hackett, & Stratton, 2009); therefore, girls may have had less gaming ability than boys at baseline. The increases in time to complete the mini-games across episodes for all children may reflect the progressive complexity of lessons across the episodes.

Strengths and Limitations

DIAB and NANO were developed from theory and research by a multidisciplinary team. Critical elements of DIAB and NANO were the knowledge mini-games. It is not known whether knowledge acquisition mediated the behavior changes experienced by youth who played DIAB and NANO, because a measure of EB knowledge was not collected in this study. However, 95–100% of the participants mastered the educational mini-games

suggesting most participants learned at least some of the EB concepts. Further, it is possible that some participants got better at playing some of the games rather than learning the concepts. Also, alpha testing was conducted in a laboratory setting with youth playing the games under observation of a research assistant and providing feedback about the mini-games to a research assistant via interview. This environment and methods may have led to positively biased responses from the participants.

Conclusion

DIAB and NANO demonstrated educational mini-games embedded in a serious video game may have the capacity to change health behaviors among children and also to be fun and engaging. Innovative features of DIAB and NANO educational mini-games were mastery learning techniques, focusing on practical EB knowledge, and embedding a debriefing feature in the game itself (i.e., goal setting task). There is a paucity of research describing the methods, theoretical foundations, and mechanics of health video games. This information is needed to develop the field and demonstrate video games are a credible public health intervention.

Acknowledgments

Funding

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This research was primarily funded by a grant from the National Institute of Diabetes and Digestive and Kidney Diseases (U44 DK66724-01). This work is also a publication of the U.S. Department of Agriculture (USDA/ARS) Children's Nutrition Research Center, Department of Pediatrics, Baylor College of Medicine, Houston, Texas, and had been funded in part with federal funds from the USDA/ARS under Cooperative Agreement No. 58-6250-6001.

References

- Ainsworth BE, Haskell WL, Whitt MC, Irwin ML, Swartz AM, Strath SJ, ... Leon AS. Compendium of physical activities: an update of activity codes and MET intensities. *Medicine and Science in Sports and Exercise*. 2000; 32(9 Suppl):S498–504. [PubMed: 10993420]
- Bandura, A. *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice Hall; 1986.
- Bandura A. Health promotion by social cognitive means. *Health Education and Behavior*. 2004; 31(2): 143–164. [PubMed: 15090118]
- Banos RM, Cebolla A, Oliver E, Alcaniz M, Botella C. Efficacy and acceptability of an Internet platform to improve the learning of nutritional knowledge in children: the ETIOBE Mates. *Health Education and Research*. 2013; 28(2):234–248.
- Baranowski T, Baranowski J, Cullen KW, Marsh T, Islam N, Zakeri I, ... deMoor C. Squire's Quest! Dietary outcome evaluation of a multimedia game. *American Journal of Preventive Medicine*. 2003; 24(1):52–61. [PubMed: 12554024]
- Baranowski T, Baranowski J, Thompson D, Buday R. Behavioral science in video games for children's diet and physical activity change: Key research needs. *Journal of Diabetes Science and Technology*. 2011; 5:5. [PubMed: 21303619]
- Baranowski T, Baranowski J, Thompson D, Buday R, Jago R, Griffith MJ, ... Watson KB. Video game play, child diet, and physical activity behavior change a randomized clinical trial. *American Journal of Preventive Medicine*. 2011; 40(1):33–38. [PubMed: 21146765]

- Barsuk JH, Cohen ER, Caprio T, McGaghie WC, Simuni T, Wayne DB. Simulation-based education with mastery learning improves residents' lumbar puncture skills. *Neurology*. 2012; 79(2):132–137. [PubMed: 22675080]
- Bartholomew LK, Gold RS, Parcel GS, Czyzewski DI, Sockrider MM, Fernandez M, ... Swank P. Watch, Discover, Think, and Act: Evaluation of computer-assisted instruction to improve asthma self-management in inner-city children. *Patient Education and Counseling*. 2000; 39(2–3):269–280. [PubMed: 11040726]
- Bloom BS. Learning for Mastery. *Evaluation Comment*. 1968; 1:1–11.
- Brown SJ, Lieberman DA, Germeny BA, Fan YC, Wilson DM, Pasta DJ. Educational video game for juvenile Diabetes: Results of a controlled trial. *Medical Informatics (London)*. 1997; 22(1):77–89.
- Cohen ER, Barsuk JH, Moazed F, Caprio T, Didwania A, McGaghie WC, Wayne DB. Making July safer: Simulation-based mastery learning during intern boot camp. *Academic Medicine*. 2013; 88(2):233–239. [PubMed: 23269294]
- Cook DA, Brydges R, Zendejas B, Hamstra SJ, Hatala R. Mastery learning for health professionals using technology-enhanced simulation: A systematic review and meta-analysis. *Academic Medicine*. 2013; 88(8):1178–1186. [PubMed: 23807104]
- Crookall D. Serious games, debriefing, and simulation/gaming as a discipline. *Simulation & Gaming: An International Journal*. 2010; 41:898–920.
- Das ND. Obesity: Genes, brain, gut, and environment. *Nutrition*. 2010:1–15.
- DeShazo J, Harris L, Pratt W. Effective intervention or child's play? A review of video games for Diabetes education. *Diabetes Technology & Therapeutics*. 2010; 12(10):815–822. [PubMed: 20807119]
- Fairclough SJ, Boddy LM, Hackett AF, Stratton G. Associations between children's socioeconomic status, weight status, and sex, with screen-based sedentary behaviours and sport participation. *International Journal of Pediatric Obesity*. 2009; 4(4):299–305. [PubMed: 19922045]
- Franks PW, Hanson RL, Knowler WC, Moffett C, Enos G, Infante AM, ... Looker HC. Childhood predictors of young-onset type 2 Diabetes. *Diabetes*. 2007; 56(12):2964–2972. [PubMed: 17720898]
- Gonzales EN, Marshall JA, Heimendinger J, Crane LA, Neal WA. Home and eating environments are associated with saturated fat intake in children in rural West Virginia. *Journal of the American Dietetic Association*. 2002; 102(5):657–663. [PubMed: 12008990]
- Harrell JS, McMurray RG, Bangdiwala SI, Baggett C, Pearce PF, Pennel M. Determining MET values in children and adolescents. *Medicine and Science in Sports and Exercise*. 2003; 35:s342.
- Hussain A, Claussen B, Ramachandran A, Williams R. Prevention of type 2 Diabetes: a review. *Diabetes Research and Clinical Practice*. 2007; 76(3):317–326. [PubMed: 17069920]
- Jago R, Baranowski T, Baranowski J, Thompson D, Cullen K, Watson K, Liu Y. Fit for life Boy Scout badge: Outcome Evaluation of a troop & internet intervention. *Preventive Medicine*. 2006a; 42:181–187. [PubMed: 16458955]
- Jago R, Baranowski T, Baranowski JC, Thompson D, Cullen KW, Watson K, Liu Y. Fit for Life Boy Scout badge: outcome evaluation of a troop and Internet intervention. *Preventive Medicine*. 2006b; 42(3):181–187. [PubMed: 16458955]
- Kato PM, Beale IL. Factors affecting acceptability to young cancer patients of a psychoeducational video game about cancer. *Journal of Pediatric Oncology Nursing*. 2006; 23(5):269–275. [PubMed: 16902082]
- Kato PM, Cole SW, Bradlyn AS, Pollock BH. A video game improves behavioral outcomes in adolescents and young adults with cancer: a randomized trial. *Pediatrics*. 2008; 122(2):e305–317. [PubMed: 18676516]
- Krebs NF, Himes JH, Jacobson D, Nicklas TA, Guilday P, Styne D. Assessment of child and adolescent overweight and obesity. *Pediatrics*. 2007; 120(Suppl 4):S193–228. [PubMed: 18055652]
- LeJeune N. Contract grading with mastery learning in CSI. *Journal of Computing Sciences in Colleges*. 2010; 26:149–156.

- Lin CH, Liu EZF, Chen YL, Liou PY, Chang M, Wu CH, Yuan SM. Game-based remedial instruction in mastery learning for upper-primary school students. *Journal of Educational Technology & Society*. 2013; 16(2):271–281.
- Matvienko O. Impact of a nutrition education curriculum on snack choices of children ages six and seven years. *Journal of Nutrition Education & Behavior*. 2007; 39(5):281–285. [PubMed: 17826348]
- McGaghie WC, Issenberg SB, Cohen ER, Barsuk JH, Wayne DB. Medical education featuring mastery learning with deliberate practice can lead to better health for individuals and populations. *Academic Medicine*. 2011; 86(11):e8–e9. [PubMed: 22030671]
- McPherson AC, Glazebrook C, Forster D, James C, Smyth A. A randomized, controlled trial of an interactive educational computer package for children with asthma. *Pediatrics*. 2006; 117(4):1046–1054. [PubMed: 16585298]
- Morrongiello BA, Schwebel DC, Bell M, Stewart J, Davis AL. An evaluation of The Great Escape: can an interactive computer game improve young children's fire safety knowledge and behaviors? *Health Psychology*. 2012; 31(4):496–502. [PubMed: 22468715]
- Nabors LA, Kockritz JL, Ludke RL, Bernstein JA. Enhancing school-based asthma education efforts using computer-based education for children. *Journal of Asthma*. 2012; 49(2):209–212. [PubMed: 22211479]
- Nelson MC, Lytle LA, Pasch KE. Improving literacy about energy-related issues: the need for a better understanding of the concepts behind energy intake and expenditure among adolescents and their parents. *Journal of the American Dietetic Association*. 2009; 109(2):281–287. [PubMed: 19167955]
- Panic K, Cauberghe V, De Pelsmacker P. Promoting dental hygiene to children: comparing traditional and interactive media following threat appeals. *Journal of Health Communication*. 2014; 19(5): 561–576. [PubMed: 24393019]
- Peng W. Design and evaluation of a computer game to promote a healthy diet for young adults. *Health Communication*. 2009; 24(2):115–127. [PubMed: 19280455]
- Peters VA, Vissers GAN. A simple classification model for debriefing simulation games. *Simulation & Gaming: An International Journal*. 2004; 35:70–84.
- Primack BA, Carroll MV, McNamara M, Klem ML, King B, Rich M, ... Nayak S. Role of video games in improving health-related outcomes: a systematic review. *American Journal of Preventive Medicine*. 2012; 42(6):630–638. [PubMed: 22608382]
- Quarry-Horn JL, Evans BJ, Kerrigan JR. Type 2 Diabetes mellitus in youth. *Journal of School Nursing*. 2003; 19(4):195–203. [PubMed: 12882602]
- Roberts D, Foehr U, Rideout V. Generation M: Media in the lives of 8–18 year olds. Kaiser Family Foundation Study. 2005:12.
- Rodriguez GLA, Moreno A, Sarria A, Fleta J, Bueno M. Resting energy expenditure in children and adolescents: Agreement between calorimetry and prediction equations. *Clinical Nutrition*. 2002; 21:255–260. [PubMed: 12127936]
- Schofield WN. Predicting basal metabolic rate, new standards and review of previous work. *Human Clinical Nutrition*. 1985; 39:5–42. [PubMed: 4044297]
- Serrano E, Anderson J. The evaluation of food pyramid games, A bilingual computer nutrition education program for Latino youth. *Journal of Family and Consumer Sciences Education*. 2004; 22:1–16.
- Slater ME, Sirard JR, Laska MN, Pereira MA, Lytle LA. Relationships between energy balance knowledge and the home environment. *Journal of the American Dietetic Association*. 2011; 111:556–560. [PubMed: 21443988]
- Stinson JN, Petroz GC, Tait G, Feldman BM, Streiner D, McGrath PJ, Stevens BJ. e-Ouch: usability testing of an electronic chronic pain diary for adolescents with arthritis. *Clinical Journal of Pain*. 2006; 22(3):295–305. [PubMed: 16514331]
- Thompson D, Baranowski T, Baranowski J, Cullen K, Jago R, Watson K, Liu Y. Boy Scout 5-a-Day Badge: outcome results of a troop and Internet intervention. *Preventive Medicine*. 2009; 49(6): 518–526. [PubMed: 19765608]

- Thompson D, Baranowski T, Buday R. Conceptual model for the design of a serious video game promoting self-management among youth with type 1 Diabetes. *Journal of Diabetes Science and Technology*. 2010; 4(3):744–749. [PubMed: 20513343]
- Thompson D, Baranowski T, Buday R, Baranowski J, Thompson V, Jago R, Griffith MJ. Serious Video Games for Health How Behavioral Science Guided the Development of a Serious Video Game. *Simulation & Gaming: An International Journal*. 2010; 41(4):587–606.
- Turnin MC, Tauber MT, Couvaras O, Jouret B, Bolzonella C, Bourgeois O, ... Hanaire-BROUTIN H. Evaluation of microcomputer nutritional teaching games in 1,876 children at school. *Diabetes Metabolism*. 2001; 27(4 Pt 1):459–464. [PubMed: 11547219]
- United States Department of Agriculture and the Department of Health and Human Services. *Dietary Guidelines for Americans*. Washington, DC: Government Printing Office; 2005.
- Vandelandotte C, De Bourdeaudhuij I. Acceptability and feasibility of a computer-tailored physical activity intervention using stages of change: project FAITH. *Health Education and Research*. 2003; 18(3):304–317.
- Wambugu PW, Changeiywo JM. Effects of mastery learning approach on secondary school students' physics achievement. *Journal of Mathematics, Science & Technology Education*. 2008; 43:293–302.
- Williams O, Hecht MF, DeSorbo AL, Huq S, Noble JM. Effect of a novel video game on stroke knowledge of 9- to 10-year-old, low-income children. *Stroke*. 2014; 45(3):889–892. [PubMed: 24481976]

Biographies

Tracey Ledoux, PhD, RD, FAND, is an assistant professor of nutrition at the University of Houston. She has been in this position for over five years. Previously she had the honor of completing a two year postdoctoral research fellowship in behavioral nutrition under the mentorship of Tom Baranowski, PhD at the Children's Nutrition Research Center USDA/ARS, Baylor College of Medicine.

Contact: TALedoux@uh.edu

Melissa Juliano Griffith, MPH received her graduate degree from the University of Texas at Houston, School of Public Health. She conducted and analyzed, as her thesis research, the alpha-testing of the Escape from DIAB and Nanoswarm games. She was a research coordinator with Children's Nutrition Research Center USDA/ARS, Baylor College of Medicine for 5 years.

Contact: Melissa_juliano@yahoo.com

Debbe Thompson, PhD, is a USDA/ARS scientist with a faculty appointment as Associate Professor at Baylor College of Medicine. She has designed and tested technology-related interventions since 2001.

Contact: dit@bcm.edu

Nga Nguyen, MS, is a senior statistical analyst at Department of Biostatistics, The University of Texas MD Anderson Cancer Center. She has been in this position for five years. Previously she worked as a statistician at the Children's Nutrition Research Center USDA/ARS, Baylor College of Medicine.

Contact: Ntnghuyen1@mdanderson.org

Kathy Watson is an epidemiologist with the Centers for Disease Control and Prevention (CDC) where her work is focused on physical activity surveillance. Prior to CDC, and where her work on this study was performed, she was a faculty instructor/senior biostatistician at the Children's Nutrition Research Center USDA/ARS, Baylor College of Medicine.

Contact: kwatson@cdc.gov

Janice Baranowski, MS, RD, is an Assistant Professor of Behavioral Nutrition at the USDA/ARS Children's Nutrition Research Center, Department of Pediatrics, Baylor College of Medicine. She has been involved with games and health behavior change for the last 20 years.

Contact: jbaranow@bcm.edu

Richard Buday, FAIA is president and founder of Archimage, a 31-year-old digital arts studio and recipient of 40 international awards for design. Richard has been principal investigator of \$11 million in health video game grants and taught at the University of Houston for 15 years.

Contact: Rbuday@Archimage.com

Dina Abdelsamad, MPH, PA-C is currently a physician assistant working in the emergency department at Johns Hopkins University in Baltimore, MD. Prior to attending graduate school, she was assisting with and coordinating various research studies at Baylor College of Medicine Children's Nutrition Research Center for over four years.

Contact: dina.abdelsamad@gmail.com

Tom Baranowski, PhD, is Professor of Pediatrics with the Baylor College of Medicine, Houston. He has been engaged in research on various games for health since 1997. He is Editor-in-Chief of the *Games for Health Journal*.

Contact: tbaranow@bcm.edu

Figure 1.
“What counts as a fruit?” mini game from DIAB.

Figure 2.
“Fruit and vegetables in a fast food restaurant” from NANO.

Figure 3.
“Lifepad snack bar” mini game in NANO.

Escape from Diab Energy Balance Games.

		Sessions/Episodes																	
		1	2	3	4	5	6	7	8										
		EB. Vegetable, water, fruit, grain, and meat portions for dinner																	
		EB. Vegetable portions for a snack	EB. Fruit and dairy portions for breakfast	EB. Water, grains, and meat portions for lunch	EB. Vegetable, water, fruit, grain, and meat portions for dinner														
Name and Topic		Activity Balance. Physical inactivity (PI) goals								Activity Balance. PA goals		Activity Balance. Balancing energy intake and energy expenditure	Activity Balance. Balancing energy intake and energy expenditure						
Learning objectives. After playing the game, children will be able to...	1	Report recommended food group portions for age and weight status for each meal/snack.								1	Report their recommended minimum daily amount of PA.	1	Report on how much PA is necessary to burn off their usual snack or meal.						
	2	Report how their normal food and portion choices compare to those food and portions choices recommended for their age and weight status.								2	Report how their usual after school activities compare to recommended PI levels.	2	Report how their usual after school activities compare to recommended PA levels.						
	3	Alter food and portion sizes to create a balanced meal/snack appropriate for their age and weight status.								3	Manage their time to decrease PI time.	3	Manage their time to increase PA time.						
Description		In sessions 1–4, the game player selects food items representing given food groups and then identifies portion sizes of the food items they believe are appropriate for one’s age and weight status. Food Meters aid the player in selecting appropriate portion sizes for their age and weight status.								The player selects activities they usually do outside of school from a menu of options for a school day and a non-school day. A meter tracks how much sedentary (episode 5) or moderate to vigorous (episode 6) PA the player normally schedules and indicates when it is more, less, or equal to what is recommended. The player can then make adjustments to their scheduled activities to achieve the recommended amount.								The player selects a meal with a given caloric value and an activity with a given energy expenditure value. Then the player must make his way through a maze of streets acquiring coins representing one minute of the chosen PA.	
Mechanics of Game		In sessions 1–4, the player selects a food by clicking its image on the screen. The player indicates whether they want more or less of the food item by clicking on “More” or “Less” icons. The Food Meters track and display how the adjustments to portion size and the food item selections effect the balance of the meal. When they have the desired portion size displayed, they indicate their selection by clicking the “Select” icon. With each episode the number of foods to balance increases.								The player selects and drags icons representing various physical activities to a daily schedule time table broken into 15-minute (episode 5) or 30-minute (episode 6) increments. As the time table fills, the activity meter tracks now much PI (episode 5) or PA (episode 6) is scheduled per day. The player makes changes to the time table schedule to achieve the activity goals.								On the first screen the player clicks on icons to select meals and activities. On the second screen, the player uses the joystick to maneuver a character through the city streets. Another joystick is used to view different aspects of the scene. To receive a coin, the player simply walks DJ over it.	

Sessions/Episodes							
Name and Topic	1	2	3	4	5	6	7
	EB. Vegetable portions for a snack	EB. Fruit and dairy portions for breakfast	EB. Water, grains, and meat portions for lunch	EB. Vegetable, water, fruit, grain, and meat portions for dinner	Activity Balance. Physical inactivity (PI) goals	Activity Balance. PA goals	Activity Balance. Balancing energy intake and energy expenditure
Criterion Goal	One balanced Food Meter representing an appropriate portion of vegetables for a snack for the player's given age and weight status. No time limit.	Two balanced Food Meters representing appropriate portions of fruit and dairy for breakfast for a player's given age and weight status. No time limit.	Three balanced Food Meters representing appropriate portions of water, grain, and meat foods for lunch for a player's given age and weight status. No time limit.	Five balanced Food Meters representing appropriate portions of vegetable, water, fruit, grain, and meat foods for dinner for a player's given age and weight status. No time limit.	Two balanced PI meters indicating 120 minutes of PI scheduled for school days and non-school days. No time limit.	Two balanced PA meters indicating >60 minutes of PA scheduled for school days and non-school days. No time limit.	A coin represents one minute of the chosen PA. The number of coins needed to win the game is equal to the number of minutes the player would need to do that activity (based on their age and weight status) to burn the number of calories in the meal they selected. The goal is to gather the appropriate number of coins before time runs out.

Note. EB: Energy Balance game; PA: Physical Activity; PI: Physical Inactivity

Table 2

Escape from Diab Nutrition Knowledge Games.

Name	Episode 1		Episode 2		Episode 3		Episode 4	
	What Counts as a Vegetable?	What Counts as a fruit?	Press your Portions: Vegetables.		Press your Portions: Fruit.		Press your Portions: Fruit.	
Description	DJ finds his way through maze of streets by following paths indicated by healthy vegetable choices (e.g., broccoli) and avoiding the paths marked by unhealthy vegetable choices. When the wrong choice is made mean robots are released.	DJ runs through a warehouse and selects 20 healthy fruits from the shelves stocked with healthy and unhealthy fruit.	Stop a spinning wheel to select a vegetable (episode 3) or fruit (episode 4). Then select from another wheel, the correct portion for the selected food item.					
Learning objective After playing the game children will be able to...	To discriminate healthy and unhealthy vegetables.	To discriminate healthy and unhealthy fruits.	To recognize correct serving/portions sizes for various vegetables (episode 3) and fruits (episode 4).					
Mechanics	The player uses the joystick to guide the character through the maze. Healthy or unhealthy vegetable selections are made by guiding the character down streets marked with pictures of the healthy or unhealthy choice. When an unhealthy selection is made a big red X fills the screen with an image of a mean robot.	The player uses the joystick to guide the character through the warehouse. Choosing a fruit involves standing near it and pushing a button on the controller.	The player is shown a wheel with different kinds of vegetables or fruits represented by wedges in the wheel. An arrow spins around the wheel and the player presses a button on the controller to indicate when they want the spinner to begin to stop. Once the spinner has stopped, whatever vegetable or fruit it is pointing at, is the vegetable or fruit selected. The second wheel has several serving sizes displayed around it and are randomly being lit up. The player selects the portion size they believe corresponds with the vegetable they selected by pressing a button on the controller when it is lit up.					
Criterion Goal	20 correct vegetable selections in less than 3 minutes. Correct selections are displayed at the end of the game.	20 correct fruit selections in less than 3 minutes.	Correctly identified portions for four selected vegetables. Players are not penalized for incorrect selections, and given the opportunity to try again.		Correctly identified portions for five selected fruits. Players are not penalized for incorrect selections, and given the opportunity to try again.			

Table 3

Escape from Diab PA Knowledge Games.

Name	Episode 5		Episode 6		Episode 7		Episode 8	
	Home Exercise	Breakthrough: Aerobic	Breakthrough: Strength	Decreasing Physical Inactivity				
Description	The player moves common household items (i.e., TV, bed, chair, dresser, matt, cans) around rooms to get another character in the game to demonstrate how they are used as an exercise tool.	The player moves a ball around the screen with the aim of rolling over images of aerobic activities and avoiding images of non-aerobic activity.	The player moves a ball around the screen with the aim of rolling over images of strength building activities and avoiding images of non-strength-building activity.	The player's character runs around tagging physically inactive kids in a playground. Tagging the kids makes them initiate moderate to vigorous activities for a finite amount of time before they require being tagged again.				
Learning objective After playing the game children will be able to...	Identify ways to be active in the home.	Discriminate aerobic activities from other types of activities.	Discriminate strength building activities from other types of activities.	Discriminate physically active versus inactive activities.				
Mechanics	The player uses a joystick on the controller to move their character through each room and uses a button on the controller to select items to be pushed or dragged around each room.	The player uses a joystick to move the ball around the screen.	The player uses a joystick to move the ball around the screen.	The player uses the joystick to move the player around the screen. The other characters are considered "tagged" when the player's character runs up to them.				
Criterion Goal	Each room is timed, so all items in the room must be moved to the other character before time runs out. When all items are correctly identified and moved, the game reviews them all and their uses before the player moves on.	Roll over 20 aerobic activity images to win but roll over too many non-aerobic activity images and you lose.	Roll over 20 strength building activity images to win but roll over too many non-strength building activity images and you lose.	The goal of the game is to fill up an activity meter. Six or more characters or dyads of characters need to be engaging in physically active activities for the activity meter to increase. When less than six are active, the meter goes down. The player's character must continuously run around the playground tagging characters to maintain 6 or more going at a time as they only stay active for several seconds at a time before becoming inactive again.				

Table 4

Nanoswarm Energy Balance Games.

Name	Sessions								
	1	2	3	4	5	6	7	8	9
Description of Game	<p>Ledge: Cafeteria Ledge: Hamburger Grill Ledge: Fried Chicken Ledge: Pizzeria</p> <p>On the first screen the player's character selects a meal with a given calorie content and an activity with a given energy expenditure. On the second screen, the player's character is in a room with moving ledges on each wall. The player runs and flies around the room with his/her jetpack collecting coins which represent units of the chosen PA. When enough activity coins are collected to represent the energy content of the selected meal, the player is able to jump into the "goal achieved" window in the wall.</p>								
Learning objectives	<p>1 Discriminate healthy vs. unhealthy meals for a person of their weight status & gender.</p> <p>2 Report how long they would need to engage in different activities to balance the calories from a given meal.</p> <p>3 Report on the effects of meal content on total calories in a meal and activity necessary to burn those calories.</p>								
After playing the game children will be able to...	<p>1 Report on recommended meal portions for their weight status and gender.</p> <p>2 Manipulate portions to meet recommendations.</p> <p>3 Balance food group</p>								
EB Simulator (Fried Chicken meal)	On the first screen, the player selects a restaurant meal, an activity, and duration of activity. The player is then taken to a screen that requires them to select a main course, two sides, dessert, and/or beverages; and portion sizes of each until the meal and the activity are balanced. Food meters to the right indicate how balanced the meal is for each food group as the player makes and adjusts their selections.								
EB Simulator (Mexican Food meal)	The player balances calories (episode 7) and food (episode 8) across all meals by altering the amount eaten at breakfast, lunch, dinner and one snack. Food meters to the right indicate how balanced the intake vs. activity is with recommended calorie and activity levels for someone of their gender and weight status for the day.								
EB Simulator (Chinese Food meal)	The player selects a whole meals and one snack to balance all food groups, and total calories. The player also selects, and activity and duration of activity to balance energy intake. When all food groups, calories, and activity levels are balanced, the game is over. In this final episode the Food meters are hidden and only when the player thinks they are finished will the meters indicate how well they are doing. Player is limited to the extent they can view the food meters.								
EB Simulator (Balancing a day's food intake across all meals.)	Report recommended daily calories and food group servings for their weight status and gender.								
EB Simulator (Balancing a day's food intake across all meals.)	Manipulate portions to meet recommendations.								

Sessions									
	1	2	3	4	5	6	7	8	9
Name	Ledge: Cafeteria	Ledge: Hamburger Grill	Ledge: Fried Chicken	Ledge: Pizzeria	EB Simulator (Fried Chicken meal)	EB Simulator (Mexican Food meal)	EB Simulator (Chinese Food meal)	EB Simulator (Balancing a day's food intake across all meals.)	EB Simulator (Balancing a day's food intake across all meals.)
Mechanics of Game	The player uses one joystick to run or fly and the second joy stick to view different aspects of the scene. A button on the controller allows the player's character to jump to select coins.				4	4	Report how selecting a healthy vs. unhealthy food alters EB.	3	Balance selections by decreasing/increasing food portion sizes. Report how selecting a healthy vs. unhealthy food alters EB.
Criterion Goal	The goal is to gather enough activity coins to balance the energy for the selected meal. No time limit.				Select foods by clicking on their images and then click displayed portion sizes to select portions.			Select meals by clicking on their images and then click displayed portion sizes to select portions.	Select meals by clicking on their images and then click displayed portion sizes to select portions.
					When all food and activity meters are balanced the game is over.			When all calorie, food, and activity meters are balanced the game is over.	When all food meter balance beam bars are balanced the game is over. However, players are only given three opportunities to achieve goals of game. After three failures, the player is told, "Wings, it didn't have to end this way. Life is like a game. Would you like to play again?" And, the player is only given a "yes" option.

Note. EB: Energy Balance

Table 5

Nanoswarm Nutrition Knowledge Games

Name	Episode 1		Episode 2		Episode 3	Episode 4	
	Fruit and Vegetable in a Fast Food Restaurant		Lifepad snack bar		Analyzing Nutrition Information	Picking Healthy Takeout Food	
Description	Select healthy desserts, sides, and drinks by clicking on their moving images. Clicking on an unhealthy choice results in a buzzing noise to indicate the poor selection.		A grid of healthy and unhealthy snack bar food images are presented with one blank space. The player is to slide food tiles around the grid, using the one “free” space to move healthy choices out of the grid.		A nutrition facts label is presented and the player identifies three unhealthy components (e.g., >30% total fat). Hints to the side of the screen aid the player in evaluating and determining which aspects of the label indicate an unhealthy feature of the food item.	The player selects the type of takeout restaurant they want to order from: Cafeteria, Fried Chicken, Hamburger Grill, or a Taco Stand. A grid of healthy and unhealthy cafeteria food images are presented with one blank space. The player is to slide food tiles around the grid, using the one “free” space to move healthy choices out of the grid.	
Learning objectives After playing the game children will be able to ...	Discriminate between healthy and unhealthy food choices.		Discriminate between healthy and unhealthy snack food choices.		Identify information from a food label that would indicate unhealthy qualities of the food it describes.	Discriminate between healthy and unhealthy food choices found in a cafeteria.	
Mechanics	The player uses a button on the controller to click images of healthy foods. The joystick positions the cursor.		The player uses a button on the controller to click arrows on the screen indicating which direction the tiles will move when selected. When a healthy food item is placed in the <i>select</i> space, the player clicks the button on the controller to remove that food from the grid.		The player uses the joystick to move the cursor around the screen. As the cursor glides over components of the food label the components light up. When the player wishes to select a component as “unhealthy,” they click a button on their controller while the cursor is highlighting that component.	The player uses a button on the controller to click arrows on the screen indicating which direction the tiles will move when selected. When a healthy food item is placed in the “select” space, the player clicks the button on the controller to remove that food from the grid.	
Criterion Goal	Need to select 7 healthy desserts, 13 healthy sides, and 6 healthy drinks. Player needs to restart after 5 mistakes.		Release 5 healthy snack food choices from the grid. Players can mistakenly release up to 3 unhealthy choices before having to start over. When players make 3 unhealthy selections they are told why those items are unhealthy before starting over.		Three unhealthy label items need to be identified in less than one minute to complete the game. Incorrect choices are not penalized. If the player does not finish in one minute they must start over.	Release 5 healthy snack food choices from the grid. Players can mistakenly release up to 3 unhealthy choices before having to start over. When players make 3 unhealthy selections they are told why those items are unhealthy before starting over.	

Table 6

Nanoswarm PA Knowledge Games

Episode 5		Episode 6		Episode 7		Episode 8	
Name	PA in the Lifepad	No Transportation	Not Enough Time	Reasons for Not Exercising			
Description	Select physical activities that could be done in the home using common household items by first selecting a household item and then clicking on moving images of activities that could be done using that item. Clicking on sedentary activities results in the activity's image freezing in place creating an obstacle.	A transcript of dialogue between the player and a friend is presented on the top portion of the screen. The friend initiates the conversation by posing a problem they are having with finding transportation to exercise. The player must select their verbal response from a list of options on the bottom half of the screen. The friend responds either with an enthusiastic acceptance of the solution or with reasons why the player is not optimal. In that case the player is then required to select another response. This continues until the player selects the most desirable and effective solution to the problem presented by the friend.	Select puzzle pieces representing various daily activities (e.g., doing homework, watching TV) and fit them into a puzzle representing a full days schedule. Once complete new puzzle pieces representing exercise activities are presented and the player is to replace some of the pieces already in the puzzle so that the total day's schedule includes 60 minutes of exercise. Only some activities of the normal day can be replaced, however, so the player must determine which activities like watching TV can be replaced with exercise and which should not like doing homework. The player does this task for school and non-school days.	A transcript of dialogue between the player and a friend is presented on the top portion of the screen. The friend initiates the conversation by posing a problem they are having with being able to exercise. The player must select their verbal response from a list of options on the bottom half of the screen. The friend responds either with an enthusiastic acceptance of the solution or with reasons why the solution selected by the player is not optimal. In that case the player is then required to select another response. This continues until the player selects the most desirable and effective solution to the problem presented by the friend.			
Learning objectives After playing the game children will be able to ...	Name physical activities that could be done in the home using common household items.	Name solutions to overcoming a transportation barrier to exercising.	Adjust a daily schedule to fit 60 minutes of PA into the day while still meeting the demands of school and family life.	Name solutions for overcoming various barriers to exercising.			
Mechanics	The player selects a household item (i.e., bed, dresser, chair, mat). Exercises and sedentary activities that could be done using that particular item are then displayed on moving targets. The player uses a button on the controller to click the exercise images. The joystick positions the cursor.	The player selects multiple choice responses by moving the cursor over the desired response with the joystick and then selecting it by hitting a button on the controller.	The player selects puzzle pieces using a button on the controller and uses the joystick to move them into place on the puzzle.	The player selects multiple choice responses by moving the cursor over the desired response with the joystick and then selecting it by hitting a button on the controller.			
Criterion Goal	If the player incorrectly chooses 5 inactive options, they lose and must start over. When they choose 10 active options, they advance.	The player moves to the next game when the most desirable solution is given to the friend. The game is based on trial and error, so there are not penalties or ways to lose the game.	The player moves to the next game when three days of schedules are acceptably adjusted to include 60 minutes of exercise without eliminating essential activities like eating and homework.	The player moves to the next game when the most desirable solution is given to the friend. The game is based on trial and error, so there are not penalties or ways to lose the game.			

Table 7

Means (M) and Standard Deviations (SD) of Number of Attempts and Minutes to Complete Each Game per Episode in DIAB

		Number of attempts						Minutes to complete					
		Completers			By Gender			Completers			By Gender		
					Female						Female		
					Male						Male		
Episode	Module name	n	M (SD)	n	M(SD)	n	M(SD)	n	M(SD)	n	M(SD)	n	M(SD)
1	Fruit and Vegetable in a Fast Food Restaurant	100	0.00 (0.00)	44	0.00 (0.00)	56	0.00 (0.00)	100	1.50 (1.82)	44	1.80 (2.57)	56	1.27 (0.81)
1	Ledge	100	2.01 (1.90)	44	1.77 (1.68)	56	2.20 (2.05)	100	4.30 (2.38)	44	4.50 (2.57)	56	4.15 (2.22)
2	Ledge	99	0.00 (0.00)	43	0.00 (0.00)	56	0.00 (0.00)	98	1.94 (1.16)	43	1.81 (1.10)	55	2.04 (1.20)
2	Mix And Match At The Life Pad Snack Bar	99	3.22 (3.71)	43	4.35 (4.67)	56	2.36 (2.47)	99	8.89 (11.53)	43	11.77 (16.24)	56	6.69 (4.87)
3	Analyzing Nutritional Information	99	0.00 (0.00)	43	0.00 (0.00)	56	0.00 (0.00)	99	5.22 (6.66)	43	6.00 (9.16)	56	4.63 (3.75)
3	Ledge	100	0.00 (0.00)	44	0.00 (0.00)	56	0.00 (0.00)	99	2.86 (0.89)	43	2.82 (0.90)	56	2.90 (0.89)
4	Ledge	100	0.00 (0.00)	44	0.00 (0.00)	56	0.00 (0.00)	100	5.88 (4.10)	44	5.64 (2.87)	56	6.07 (4.87)
4	Picking Healthy Takeout Food	99	0.00 (0.00)	43	0.00 (0.00)	56	0.00 (0.00)	99	3.17 (2.11)	43	3.00 (0.76)	56	3.30 (2.73)
5	EB Simulator	99	0.56 (0.98)	43	0.65 (1.07)	56	0.48 (0.91)	98	2.47 (1.67)	42	2.45 (1.30)	56	2.49 (1.90)
5	PA In The Home	100	1.88 (3.54)	44	2.95 (4.90)	56	1.04 (1.45)	99	7.85 (3.70)	43	8.99 (4.16)	56	6.98 (3.06)
6	EB Simulator	97	0.44 (0.68)	43	0.35 (0.57)	54	0.52 (0.75)	97	2.11 (1.26)	43	2.01 (1.17)	54	2.18 (1.33)
6	Negotiation: No Transportation	98	1.76 (1.42)	44	1.77 (1.55)	54	1.74 (1.32)	98	5.96 (7.18)	44	5.42 (2.74)	54	6.41 (9.37)
7	EB Simulator	97	1.33 (3.48)	43	2.23 (4.96)	54	0.61 (1.14)	97	3.41 (4.27)	43	4.45 (5.98)	54	2.58 (1.75)
7	Tangram: Not Enough Time	97	1.92 (2.19)	43	2.09 (2.72)	54	1.78 (1.66)	96	6.96 (6.12)	43	7.63 (7.27)	53	6.41 (5.02)
8	EB Simulator - Full Day	98	2.31 (3.46)	44	3.05 (4.44)	54	1.70 (2.25)	97	5.24 (5.11)	43	6.11 (5.60)	54	4.54 (4.62)
8	Reasons For Not Exercising	98	1.00 (0.00)	44	1.00 (0.00)	54	1.00 (0.00)	96	2.31 (1.93)	43	2.64 (2.10)	53	2.04 (1.76)
9	EB Simulator - Full Day	100	0.00 (0.00)	44	0.00 (0.00)	56	0.00 (0.00)	100	1.50 (1.82)	44	1.80 (2.57)	56	1.27 (0.81)

Note.

*Time excluded 0 and outlier >= 100 minutes

Table 8

Means (M) and Standard Deviations (SD) of Number of Attempts and Minutes to Complete Each Game per Episode in NANO

		Number of attempts						Minutes to complete					
		Completers			By Gender			Completers			By Gender		
					Female						Female		
					Male						Male		
Episode	Module name	n3	M (SD)	n	M(SD)	n	M(SD)	n	M(SD)	n	M(SD)	n	M(SD)
1	Fruit and Vegetable in a Fast Food Restaurant	94	1.26 (1.76)	44	0.93 (1.91)	50	1.54 (1.58)	93	5.32 (6.18)	44	4.02 (2.22)	49	6.49 (8.12)
1	Ledge	94	0.00 (0.00)	44	0.00 (0.00)	50	0.00 (0.00)	94	6.77 (4.11)	44	7.84 (4.63)	50	5.83 (3.36)
2	Ledge	94	0.00 (0.00)	44	0.00 (0.00)	50	0.00 (0.00)	94	7.52 (10.16)	44	7.68 (6.19)	50	7.37 (12.74)
2	Mix And Match At The Life Pad Snack Bar	94	0.46 (1.18)	44	0.34 (0.53)	50	0.56 (1.54)	NA	NA	NA	NA	NA	NA
3	Analyzing Nutritional Information	94	0.24 (0.58)	44	0.32 (0.64)	50	0.18 (0.52)	93	1.27 (0.86)	44	1.42 (0.94)	49	1.14 (0.76)
3	Ledge	94	0.00 (0.00)	44	0.00 (0.00)	50	0.00 (0.00)	94	5.37 (3.00)	44	5.70 (3.56)	50	5.08 (2.40)
4	Ledge	94	0.00 (0.00)	44	0.00 (0.00)	50	0.00 (0.00)	93	5.50 (5.56)	44	5.45 (6.03)	49	5.55 (5.16)
4	Picking Healthy Takeout Food	94	0.16 (0.59)	44	0.14 (0.51)	50	0.18 (0.66)	NA	NA	NA	NA	NA	NA
5	EB Simulator	93	0.00 (0.00)	43	0.00 (0.00)	50	0.00 (0.00)	93	10.25 (10.89)	43	10.55 (12.30)	50	9.99 (9.63)
5	PA In The Home	93	4.81 (3.35)	43	4.33 (1.51)	50	5.22 (4.33)	NA	NA	NA	NA	NA	NA
6	EB Simulator	93	0.00 (0.00)	43	0.00 (0.00)	50	0.00 (0.00)	88	12.15 (11.03)	41	13.17 (12.24)	47	11.26 (9.90)
6	Negotiation: No Transportation	93	0.00 (0.00)	43	0.00 (0.00)	50	0.00 (0.00)	93	2.03 (4.49)	43	2.73 (6.53)	50	1.43 (0.68)
7	EB Simulator	93	0.00 (0.00)	43	0.00 (0.00)	50	0.00 (0.00)	91	7.46 (9.34)	43	7.19 (5.11)	48	7.70 (11.98)
7	Tangram: Not Enough Time	93	0.00 (0.00)	43	0.00 (0.00)	50	0.00 (0.00)	92	14.64 (10.31)	43	14.33 (8.75)	49	14.91 (11.59)
8	EB Simulator - Full Day	93	0.00 (0.00)	43	0.00 (0.00)	50	0.00 (0.00)	91	8.71 (10.53)	41	9.09 (12.45)	50	8.40 (8.76)
8	Reasons For Not Exercising	93	0.00 (0.00)	43	0.00 (0.00)	50	0.00 (0.00)	93	1.54 (0.82)	43	1.48 (0.63)	50	1.59 (0.96)
9	EB Simulator - Full Day	93	2.57 (2.68)	43	2.35 (3.21)	50	2.76 (2.13)	92	4.96 (5.87)	43	3.78 (1.50)	49	6.00 (7.81)