A systematized review on diabetes gamification

Shadi Asadzandi1, Shahram Sedghi*1,2, Shoaleh Bigdeli3, Mahnaz Sanjari4,5

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Abstract

**Background:** Gamification is an effective tool used to enhance the quality of education and training, to create motivation and enthusiasm, and to maintain competitiveness in the targeted population. Given that, the present study is an attempt to review gamification used in the field of diabetes systematically and its effects on the target group.

**Methods:** Articles were retrieved from eight databases via an electronic advanced search. The data were imported to Endnote; and to assess the quality of the articles, PRISMA and CASP were used. Finally, according to the inclusion criteria, the appropriate articles were selected.

**Results:** This study indicates that physical activity and nutrition were the most frequent diabetic subgroups in diabetes gamification. In addition, all diabetes gamification programs were designed to educate, teach skills and make behavior improvement in diabetics.

**Conclusion:** Diabetes gamification have the capacity to change health behaviors among all age groups and can create an innovative, attractive and interactive learning environment accompanied by fun and engagement.

**Keywords:** Gamification, Video games, Serious game, Educational game, Diabetes

**Introduction**

Reports indicate that 422 million adults are diabetic, and its prevalence among adults over 18 years has risen to 8.5% in 2014 (1). According to the Center for Disease Control and Prevention (CDC) report, about 28.8% of the world population suffers from hidden diabetes (2). The prevalence of diabetes is estimated to be 6% in the Iranian population, and it is believed that about 4 million individuals are affected (3).

Diabetes is associated with serious complications and injuries, and several studies suggest that the rate of diabetic complications will increase in the near future, and it will occur at younger ages of life (4, 5). Therefore, it is necessary for diabetic patients to control their blood glucose levels to have a normal life and avoid unnecessary treatment costs. To achieve this goal, education of diabetics and healthy individuals to manage and enhance their health literacy. In addition, it is providing disease management training for high-risk groups and patients by creating fun and entertainment.

*What is “already known” in this topic:*
Gamification increases motivation, creates fun and entertainment, and promotes learning.

*What this article adds:*
Since health is a matter of life and death and treatment is a costly process, gamification can improve public health and decrease treatment costs through training healthy individuals to manage and enhance their health literacy. In addition, it is providing disease management training for high-risk groups and patients by creating fun and entertainment.
is absolutely necessary (7-10). Today, educating people with emerging technological advances and multimedia encourages them to learn and develop an understanding of the disease, and adapt to the new information (11). Therefore, considering the high prevalence of diabetes in the world and its unwanted consequences, it is necessary to benefit from new educational technologies and instruments.

One of these technologies is gamification, which as an effective educational tool enhances the quality of education, creates motivation and enthusiasm, and develops a feeling of competition in the target population (12, 13). It has the potential to transform knowledge and educational content into personal knowledge to enable users to solve problems in an active or interactive manner (14). It should be mentioned that in addition to gamification, there are other tools such as a serious game (to combine aspects of both serious concept such as teaching, learning, communication, or further information with less entertainment (15), an educational game (for teaching the basic and certain subjects with enjoyment and pleasure (16)), game-based learning (to encourage learners to participate in learning while playing and make the learning process more interesting by adding fun (17)), that are used as tools to improve the learning process. These tools have their own specific features, but all of them have one purpose of increasing the level of learning along with increased motivation and entertainment. This study is an attempt to review and appraise all papers regarding the application of diabetes gamification, serious game, and/or educational games. In this study, diabetes gamification was examined to determine their purpose and features, their underpinning learning theories, and their impact on the target group. The main question is the effects of gamification on the target group. In this regard, the research attempts to provide a clear vision of diabetes gamifications.

**Methods**

On October 14-16, 2018, using an advanced search query, databases of PubMed, Ovid, Cochrane, Scopus, Web of Science, ProQuest, Springer, Embase, and Science Direct were searched to retrieve articles related to diabetes and games. The search operators included Booleans (AND, OR and NOT), parenthesis, and truncation. Example keywords and search query used to retrieve the papers were as follows:

("diabetes mellitus, type1" OR "diabetes mellitus, type2") AND "gamification" AND "diabetes"

Flowchart 1. Assessment and selection of papers in the field of diabetes gamification.
type2") AND ("gamifications" OR "serious games" OR "educational games" OR "video games" OR "digital games" OR "Simulation" OR "Computer-assisted gaming" OR "Serious Game(s)" OR "Educational Game(s)" OR "Role-playing game(s)" OR "Real-world game(s)" OR "massively multi player online" OR "role play simulation" OR "storytelling game")

We applied the following inclusion criteria when filtering the search results: developing or using gamification/serious game or educational game in the field of diabetes, availability of full texts of original research articles, language (English), with no limits regarding the publication time. The exclusion criteria include those which were not accessible due to sanctions. We excluded duplicates using Endnote V.7 and papers were reviewed and appraised by at least two members of the research team. Finally, inconsistencies were assessed and resolved, if there were any. The data extracted from each item were title, name(s) of author(s), publication place and year, research sample or population, type of study, objectives and research questions, and type of game. In addition, findings and results of each study were summarized and recorded in predesigned forms. The PRISMA flowchart was used to investigate the retrieval, extraction and removal steps of articles as well as the Critical Appraisal Skills Program (CASP) for assessing the quality of the articles. The entire process of retrieving and reviewing studies is indicated in Flowchart 1.

### Results

Bibliographic information of documents is presented in Table 1.

Table 1 shows that Leandro Arthur Diehl (LA Diehl) was a leading researcher in diabetes gamification with three publications related to the InsuOnline game. After him, Ch. Höchsmann, N. AOKI, and D. Thompson were in the second place with two articles. The oldest article about diabetes gamification was published in 1987. The highest rate of scientific productions in diabetes gamification was seen in 2016. Evaluation of journals showed that “Games for Health Journal: Research, Development, And Clinical Applications” published by Mary Ann Liebert Inc. has published the greatest number of articles in this field.

Classification of the retrieved data according to the names of the games and game producers and country of origin are presented in Table 2.
Game production costs were not mentioned in these articles, but the costs of playing the games in the majority of these researches were free. In addition, it was indicated that to produce an appropriate gamification, we need a team consisting of technical experts and health professionals.

Figure 1 presents the distribution of gamification producers according to the country of production. It indicates that most gamifications are produced in the USA, and the rest of the countries with the least productions (1 or 2 games) stand in lower positions.

Characteristics of gamification, including game objectives, specifications, underpinning learning theories and characteristics of participants, are presented in Table 3. This is evident from the data as presented in Table 3 that all games were designed to educate, teach skills and make behavior improvement for diabetics and they are less attended to train healthcare providers or healthy people. Ac-

Table 1. Ctd

| Row | Authors          | Title                                                                                                         | Journal                              | Year |
|-----|------------------|----------------------------------------------------------------------------------------------------------------|--------------------------------------|------|
| 1   | Ebrahimpour, F   | Effect of Playing Interactive Computer Game on Distress of Insulin Injection Among Type 1 Diabetic Children   | Iranian Journal of Pediatrics        | 2015 |
| 2   | Diehl, L         | Effectiveness of a Serious Game for Medical Education on Insulin Therapy: a Pilot Study                         | Arch Endocrinol Metab               | 2015 |
| 3   | Höchsmann, Ch    | Cardiorespiratory Exertion While Playing Video Game Exercises in Elderly Individuals with Type 2 Diabetes      | Clinical Journal of Sport Medicine   | 2015 |
| 4   | Diehl, L         | User Assessment of "Insuonline," a Game to Fight Clinical Inertia in Diabetes: a Pilot Study                   | Games for Health Journal: Research, Development, and Clinical Applications | 2015 |
| 5   | Ebrahimpour, F   | The Design And Development of a Computer Game on Insulin Injection                                         | Electronic Physician                | 2014 |
| 6   | Patterson, D     | Using Interactive 3d Game Play to Make Complex Medical Knowledge More Accessible                            | Procedia Computer Science           | 2014 |
| 7   | Kempf, K         | Autonomous Exercise Game Use Improves Metabolic Control and Quality of Life in Type 2 Diabetes Patients - a Randomized Controlled Trial | BMC Endocrine Disorders           | 2013 |
| 8   | Anderson-Haney, C| Neuropsychological Benefits of Stationary Bike Exercise and a Cybercycle Exergame for Older Adults with Diabetes: an Exploratory Analysis | Journal of Diabetes Science and Technology | 2012 |
| 9   | Noah, J          | Vigorous Energy Expenditure with a Dance Exergame                                                          | Journal of Exercise Physiology Online | 2011 |
| 10  | Johnston, H      | Pose Presentation for A Dance-Based Massively Multiplayer Online Exergame                                   | Entertainment Computing            | 2011 |
| 11  | Fuchslocher, A   | Serious Games for Health: an Empirical Study of The Game “Balance” for Teenagers with Diabetes Mellitus       | Entertainment Computing            | 2011 |
| 12  | Klingensmitha, G | Evaluation of a Combined Blood Glucose Monitoring and Gaming System (Dudget®) for Motivation in Children, Adolescents, and Young Adults with Type 1 Diabetes | Pediatric Diabetes                | 2011 |
| 13  | Thompson, D      | Serious Video Games for Health How Behavioral Science Guided The Development of a Serious Video Game         | Simul Gaming                       | 2010 |
| 14  | Deshazo, J       | Designing and Remotely Testing Mobile Diabetes Video Games                                                | Journal of Telemedicine and Telecare | 2010 |
| 15  | Thompson, D      | In Pursuit of Change: Youth Response to Intensive Goal Setting Embedded in a Serious Video Game               | Journal of Diabetes Science and Technology | 2007 |
| 16  | Aoki, N          | Insulot: a Cellular Phone-Based Edutainment Learning Tool for Children with Type 1 Diabetes                 | Diabetes Care                      | 2005 |
| 17  | Aoki, N          | Edutainment Tools for Initial Education of Type-1 Diabetes Mellitus: Initial Diabetes Education With Fun      | Studies in Health Technology and Informatics | 2004 |
| 18  | Sherwood, N      | Development And Implementation of a Visual Card sorting Technique for Assessing Food and Activity Preferences and Patterns in African American Girls | Journal of The American Dietetic Association | 2003 |
| 19  | Brown, S, J      | Educational Video Game for Juvenile Diabetes: Results of a Controlled Trial                                 | JMIR Medical Informatics           | 1997 |
| 20  | Boswell, E       | The Activity: a Tool for Teaching How to Adjust for Exercise Variations                                      | The Diabetes Educator              | 1997 |
| 21  | Davidson, N      | Games: Teaching Strategy for Professionals                                                                  | The Diabetes Educator              | 1989 |
| 22  | Wheeler, L       | Betakid&mdash;Lessons Learned While Developing a Microcomputer Pediatric Case Simulation                    | The Diabetes Educator              | 1987 |

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### Table 2. The names of the games and the countries of origin in the field of diabetes

| Row | Title                                                                 | Game name                        | Developing Team                                                                 | Country production |
|-----|----------------------------------------------------------------------|----------------------------------|--------------------------------------------------------------------------------|--------------------|
| 1.  | Design And Evaluation of a Pervasive Coaching and Gamification Platform for Young Diabetes Patients | Virtual coach                    | Not Mentioned                                                                   | England            |
| 2.  | InsuOnline, an Electronic Game for Medical Education on Insulin Therapy: a Randomized Controlled Trial with Primary Care Physicians | InsuOnline                        | Clinical endocrinologists, game designers, experts in medical education, and programmers, graphic designers, sound editors | Not Mentioned      |
| 3.  | A Team-Based Online Game Improves Blood Glucose Control in Veterans with Type 2 Diabetes: a Randomized Controlled Trial | DSME game                        | Not Mentioned                                                                   | USA                |
| 4.  | An Augmented Reality Game to Support Therapeutic Education for Children With Diabetes | TED                              | Experts in diet                                                                 | Venezuela          |
| 5.  | Design and Evaluation of a Personal Robot Playing a Self-Management Education Game with Children with Diabetes Type 1 | A robot                           | Not Mentioned                                                                   | Netherlands        |
| 6.  | Educational Gaming for Pharmacy Students – Design and Evaluation of A Diabetes-Themed Escape Room | The diabetes escape room          | Pharmacy Faculty members                                                         | USA                |
| 7.  | Effects of Cycling and Exergaming on neurotropic Factors in Elderly Type 2 Diabetic Men – a Preliminary Investigation | Wii Fit Plus                      | Not mentioned                                                                   | Germany            |
| 8.  | Mobile Exergaming for Health Effects of a serious game application for smartphones on physical activity and exercise adherence in type 2 diabetes mellitus—a study protocol for a randomized controlled trial | Mobigame                          | Not mentioned                                                                   | Switzerland        |
| 9.  | An Educational Video Game for Nutrition of Young People: Theory and Design | -Escape from DIAB -Nanoswarm      | Nutrition and physical activity experts, with a game development company (Archimage Inc.) | USA                |
| 10. | Concept Development of The Eindhoven Diabetes Education Simulator Project | Eindhoven Diabetes Education Simulator (E-DES) | Not Mentioned                                                                   | Denmark            |
| 11. | Diabetic Mario: Designing and Evaluating Mobile Games for Diabetes Education | Mario Brothers                   | Not mentioned                                                                   | New Zealand        |
| 12. | Impact of a Serious Videogame Designed for Flexible Insulin Therapy on the Knowledge and Behaviors of Children with Type 1 Diabetes: The LUDIDIAB Pilot Study | L’Affaire Birman                  | An academic diabetes care team, including physicians, dieticians, nurses, and expert patients with diabetes. Game play, graphic design, soundscapes, and story. | France             |
| 13. | Acceptability and Applicability of An American Health Videogame with Story for Childhood Obesity Prevention Among Hong Kong Chinese Children Research | Diab                              | Not mentioned                                                                   | USA                |
| 14. | Effect of Playing Interactive Computer Game on Distress of Insulin Injection Among Type 1 Diabetic Children | Koodak-e-Tavana                   | Not mentioned                                                                   | Iran               |
| 15. | Effectiveness of A Serious Game for Medical Education on Insulin Therapy: a Pilot Study | InsuOnline                        | Clinical endocrinologists, game designers, experts in medical education, and programmers, graphic designers | Brazil             |
| 16. | Cardiorespiratory Exertion While Playing Video Game Exercises in Elderly Individuals with Type 2 Diabetes | Nintendo Wii Fit Plus             | Not mentioned                                                                   | USA                |
| 17. | User Assessment of InsuOnline, a Game to Fight Clinical Inertia In Diabetes: a Pilot Study | InsuOnline                        | Clinical endocrinologists, game designers, experts in medical education, and programmers, graphic designers | Brazil             |
| 18. | The Design and Development of a Computer Game on Insulin Injection | Koodak-e-Tavana                   | Not mentioned                                                                   | Iran               |
| 19. | Using Interactive 3d Game Play to Make Complex Medical Knowledge More Accessible | Diabetes Visualizer              | Not mentioned                                                                   | Australia          |

According to the title or game features, some games are considered as educational games such as the diabetes escape room, Escape from DIAB, Nanoswarm and Packy & Marlony or some of them are serious games such as Mobigame, L’Affaire Birman, InsuOnline and Balance which means that all types of games were retrieved based on the purpose of the research. Most of these games are mobile-based; however, some of them were designed for game consoles or game boards. Assessment of learning theories used in these gamifications showed that self-determination theory was frequently applied in games such as Virtual coach, robot, Escape from DIAB and Diab. Classification of games according to Bloom’s Taxonomy of Behavioral Objectives showed that
most gamifications could be classified under a cognitive domain (application and knowledge levels); in this regard, exergames consider the psychomotor activity and could be classified under this domain. Considering the effectiveness of games, the retrieved data indicated that gamification in each platform and genre could meet the participants’ needs and encourage their participation.

According to Table 3, the target population of the gamifications was from different age groups including children, diabetic patients, and healthy people and the games were designed for medical students and residents, or students of other related medical majors. There was a marked variation in the type of diabetes and many gamifications encompassed both types. Physical activity and nutrition were the most frequent diabetic subthemes in diabetes gamifications.

Discussion
Gamification is one of the learning methods that has been much considered in recent years (18, 19). According to Gee, the purpose of gamification is to create a problem-solving environment that can be integrated with continuous

| Row | Title | Game name | Developing Team | Country production |
|-----|-------|-----------|-----------------|-------------------|
| 20. | Autonomous Exercise Game Use Improves Metabolic Control and Quality Of Life in Type 2 Diabetes Patients - a Randomized Controlled Trial | Wii Fit Plus | Not mentioned | Germany |
| 21. | Neuropsychological Benefits of Stationary Bike Exercise and a Cybercycle Exergame for Older Adults with Diabetes: an Exploratory Analysis | Cybercycle | Not mentioned | USA |
| 22. | Vigorous Energy Expenditure with a Dance Exergame | Dance Dance Revolution | Not mentioned | USA |
| 23. | Pose Presentation for a Dance-Based Massively Multiplayer Online Exergame | SNAP system | Not mentioned | Canada |
| 24. | Serious Games For Health: An Empirical Study Of The Game “Balance” for Teenagers With Diabetes Mellitus | Balance | Medical scientists and psychologists of the LMU Munich child hospital | Germany |
| 25. | Evaluation of A Combined Blood Glucose Monitoring and Gaming System (Didget®) for Motivation in Children, Adolescents, and Young Adults with Type 1 Diabetes | Didget | Not mentioned | USA |
| 26. | Serious Video Games for Health How Behavioral Science Guided The Development of a Serious Video Game | Escape From Diab | Producer, director, video artists, animators, programmers, modelers, story writers, music composers, sound editors, storyboard artists, and voice talent. | USA |
| 27. | Designing and remotely testing mobile diabetes video games | -Hangman -QuizShow -Countdown | Not mentioned | USA |
| 28. | In Pursuit of Change: Youth Response to Intensive Goal Setting Embedded in a Serious Video Game | Nanoswarm | Not mentioned | USA |
| 29. | INSULOT: a cellular phone-based edutainment learning tool for children with type 1 diabetes | INSULOT | This research was supported in part by grants from the Pfizer Health Research Foundation (Tokyo, Japan) and TOSE (Kyoto, Japan) for their support in the development of the application | Japan |
| 30. | Edutainment tool for initial education type 1 diabetes mellitus: initial diabetes with fun | -Tamagoya -Tantei -Magic Toom | Not mentioned | USA |
| 31. | Development and implementation of a visual card sorting technique for assessing food and activity preferences and patterns in African American girls | Packy & Marlon | Not mentioned | USA |
| 32. | Educational video game for juvenile diabetes: results of a controlled trial | Activity Activity | Not mentioned | USA |
| 33. | The Activity Activity: a Tool for Teaching How to Adjust for Exercise Variations | Activity Activity | Not mentioned | USA |
| 34. | Games: Teaching Strategy for Professionals | - Tic-Tac-Diabetes -What’s wrong with This Picture? -Can You Guess Your Blood Sugar? | Not mentioned | USA |
| 35. | Betakid— Lessons Learned While Developing a Microcomputer Pediatric Case Simulation | Betakid | a pediatric diabetologist, pediatric nurse clinicians, an instructional designer, and a physician | USA |
education and enjoyment for improving the learning process (20). Therefore, in this review, the features, educational aspects and effectiveness of gamification (serious, educational games) in diabetes (both types) were investigated.

In this systematized review, 1795 papers were retrieved from eight databases. After discarding unrelated papers that did not match the purposes of this study, 35 papers met the study criteria.

Assessment of characteristics and commonalities among diabetes gamification showed that they were designed as digital games, exergames requiring sensors and motion detectors, and board games. They are all problem-solving games that use the task and goal method in gamification, to deliver teaching indirectly, to help learners learn through missions, tasks, victories, and failures (21, 22). Considering the game design, all the related games, except the games for teaching physical skills (exergames), use multiple-choice questions to convey game concepts (23-25).

In addition, considering underpinning learning theories to develop gamification is crucial (26). These theories promote learning and improve skills such as problem-solving and critical thinking (27-29). In this research, all diabetes gamifications aimed at teaching a skill or concept, changing a behavior or habit positively, or enhancing disease management in the target population and most of them benefited from one or more implicit underpinning learning theories.

More, gamification targets knowledge and skills and transfers them to the learner through elements such as repetition, feedback, and entertainment. When the learner becomes skillful, knowledge and skills related to that concept become persistent in the memory so that the learner can focus on the perception and implementation of the information. On the other hand, gamification has positive effects on motivation and decision-making capabilities, because the player faces challenges that untimely enhance learning through decision-making, discovery, and trial and error (18, 30, 31). This scientific background is the backbone of the effectiveness of gamification (32-34). It is also consistent with the results of this study since the target populations of diabetes gamification could successfully receive and implement the required knowledge and skills. However, it should be noted that retention of information learned through gamification was not assessed in these studies.

Considering diabetes gamification developing team, it is revealed that in addition to the field professionals, an expert technical team, including game design experts, programmers, concept designers, art designers, graphic designer, character designer, and sound designers must be among the game production team members, because identification of the technical, artistic and aesthetic aspects of the game are of paramount importance besides mastery over the gamification topic and field, which is also associated with high financial costs. On the other hand, the use of several advanced technologies, software, and hardware increases the costs of gamification production and is highly challenging (35-37).

Research limitations include the inaccessibility of some databases that do not permit the researchers to access full texts of all related articles.

**Conclusion**

The research findings indicate that all studies confirm the effectiveness of gamification in the users' training, and of course, encourage other researchers in other clinical fields to develop gamification or serious games, especially in the disciplines where understanding and learning are tedious and challenging. Since health is a matter of life and death and treatment is a costly process, gamification can improve public health and decrease treatment costs through training healthy individuals to manage and enhance their health literacy or providing disease management training for high-risk groups and patients by creating fun and entertainment. Finally, it is suggested that in future studies on gamification, the application of learning theories in gamification and serious games be the focus of attention.
| Row | Game name | Aim/s | Features | Learning Domain (subdomain) | Learning Theory | Effectiveness | Target Audience/gender | Type of Diabetes | Target Aspects |
|-----|-----------|-------|----------|-----------------------------|----------------|--------------|----------------------|------------------|---------------|
| 1.  | Virtual coach | To Develop integrated pervasive coaching and gamification platforms in medical practice | Created with the PERGAMON framework consisting of: a web application, an Android application for gathering data from sensors. PERGAMON platform is Tasks and Goals and assigns a certain number of points. | Cognitive (Knowledge) | Self-Determination | mobile technology + web-based elements supports self-management in diabetics | Not mentioned/Both | Type 1 | Self-management and Treatment |
| 2.  | InsuOnline | To assess the effectiveness of InsuOnline as a method for on insulin therapy for diabetes, as compared with a traditional on-site educational activity | A Blender 3D app, with simple commands. Unity-based with visual elements | Cognitive (Application) | Problem-based learning | effective for medical education on insulin therapy highly | Primary care physicians with any Degree of Computer or Gaming Literacy/Both | Diabetes Mellitus | Insulin Therapy |
| 3.  | DSME game | To generate longer-term improvements in hemoglobin A1c (HbA1c) by online team-based game delivering diabetes self-management education for patients via e-mail or mobile application | An automated system with multiple-choice questions | Cognitive (Application) | Not Mentioned | To improve outcomes among geographically dispersed patients with diabetes | Patients on Oral Diabetes Medications/Male | Type 2 | Self-management and Treatment |
| 4.  | TED | To take responsibility for self-control in diabetic patients | The game runs on a mobile device with an Android Operating System and has 3 levels, each of which focuses on a food group. the three food groups are: dairy products, farina-ceous products (grains), and fruits | Cognitive (Application) | self-Determination | Children acquired new knowledge about carb choices in the short-term and facilitate in the learning process. | Children, 5-14 years old/Both | Both | Nutrition |
| 5.  | A robot | To assess a personal robot in diabetes self-management/ To Acquire knowledge about the illness | Autonomous, programmable humanoid robot with quiz, and training skills(social, individual, decision-making) | Cognitive (Application) | Self-Determination | To improve self-management and cope with illness in diabetic children | Children, 5-14 years old/Both | Both | Nutrition |
| Row | Game name | Aim/s Features | Learning Domain(subdomain) | Learning Theory | Effectiveness | Target Audience/ gender | Type of Diabetes | Target Aspects |
|------|------------|----------------|-----------------------------|-----------------|--------------|------------------------|------------------|---------------|
| 6.   | The diabetes escape room | To enhance pharmacy and inter-professional education, To increase knowledge of diabetes management | Live-action team-based games with a specific goal, as well as discovering clue and solving puzzles | Cognitive (Application) | Cognitive | increased students' knowledge of diabetes mellitus management | 7-12 Children, years old /Both | Type 1 | Self-management |
| 7.   | Wii Fit Plus | To evaluate the suitability of the Wii Fit Plus to improve cardiopulmonary fitness in type 2 diabetes | Nintendo's exergame, Combination of physical activity and video games | Cognitive (Evaluation) | Not Mentioned | Improve cardiopulmonary fitness and glucose metabolism | Third-year Professional Pharmacy Students /Both | Diabetes Mellitus | Knowledge Management |
| 8.   | Mobigame | To implement evidence-based sports scientific knowledge | A mobile system with sensor tracking to verify the execution and completion of workouts | Cognitive (Application) | Cognitive | Promoting PA* in chronic diseases | Patients, ≥65 years old/Both | Type 2 | Physical Activity |
| 9.   | Escape from DIAB /Nanoswarm | To Teach about Nutrition, physical activity and energy balance | Epic games contain nine goal-tasks episodes. Each episode contains educational mini-games on PA, nutrition and energy balance with | Cognitive (Knowledge) | self-Determination | - | Patients, 45-70 years old/Both | Type 2 | Physical Activity |
| 10.  | Eindhoven Diabetes Education Simulator (E-DES) | To generate glucose and insulin predictions based food, exercise, medication and patient characteristics | Using 8 concepts, the four concepts are a digital board game, a quiz platform, a lifestyle simulator, and a puzzle game. The Diabetes Game resulted in another digital board game, two mobile swipe games, and a fairy tale-themed adventure game | Cognitive (Knowledge) | - | Effectiveness on choosing the most promising concept from eight different options. | Children, 10-12 years old/Both | Type 2 | Nutrition |
| 11.  | Mario Brothers | To promote health-related behaviors | Open-source 2D mobile game. Three design strategies, namely Structure, Feedback, and Challenge Enhancement. The health problems to be solved by the game player. | Cognitive (Application) | Cognitive | Engaging and improving knowledge of healthy diet and lifestyle in children. Improvement of insulin and carbohydrate quantification in children with type 1 diabetes | Patients, 50–65 years old/Both | Both | Education Diabetic |
| 12.  | L’Affaire Birman | To evaluate the effect of videogame on the therapeutic knowledge and behavior of type 1 diabetes children with | Web-based free videogame based on problem-solving. Interaction is made by a semi-quantitative glycemic simulator and adapts insulin dose injection for each meal according to character's parameters | Cognitive (Evaluation) | Situated learning | - | Children, 9–13 years old/Both | Both | Education Diabetic |
| Row | Game name | Aim/s | Features | Learning Domain(sub domain) | Learning Theory | Effectiveness | Target Audience/gender | Type of Diabetes | Target Aspects |
|-----|-----------|-------|----------|----------------------------|----------------|--------------|------------------------|-----------------|----------------|
| 13. | Diab      | To lower the risk of obesity and type 2 diabetes by changing children’s diet and PA behaviors | Diab is a 4GH inside a three-dimensional setting and has nine episodes. Players guided his new friends to eat more healthily and to engage in more physical activity. | Cognitive (Application) | Social cognitive, self-determination, and persuasion | Confirmed the acceptability and applicability of Diab to Hong Kong Chinese children | Patients, 11–18 years old/ Both | Type 1 | Insulin Therapy |
| 14. | Koodak-e-Ta-vana | To reduce the behavioral distress due to insulin injection in children with type 1 diabetes | Interactive computer game, with seven parts including: paired game familiarize with equipment for insulin injection; puzzle game; question and answer game; insulin kit game; painting room; story game; simulated environment for insulin injection | Cognitive (Application) | Scaffolding | Decreasing behavioral distress induced by insulin injection in type 1 diabetic child. | Students, 9-12 years old / Both | Type 2 | Nutrition and Physical Activity |
| 15. | Inso Online | compared effectiveness of InsuOnline, as to a traditional educational activity | a Blender 3D app, with simple commands, using Unity, and visual elements | Cognitive (Application) | Problem-based learning | InsuOnline is as effective as a traditional educational activity on insulin therapy | Patients, 3-12 year/ Both | Type 1 | Insulin Injection |
| 16. | Nintendo Wii Fit Plus | To determine oxygen uptake during Wii Fit Plus use relative to VO2peak in elderly type 2 diabetic patients | Nintendo exergame, with Combination of physical activity and video games | Cognitive (Evaluation) | Not Mentioned | Improving cardiopulmonary fitness and glucose metabolism. | Undergraduate medical students and Internal Medicine residents/ Both Patients, 45 to 70 years old/ Both | Diabetes Mellitus | Insulin Therapy |
| 17. | Inso Online | To assess usability and playability of InsuOnline | A Blender 3D app, with simple commands, using Unity, and visual elements suite | Cognitive (Application) | Problem-Based Learning | was rated by users as easy to play, fun, and useful | Patients, 3-12 year/ Both | Type 2 | Physical Activity |
| 18. | Koodak-e-Ta-vana | To Aim to teach children how to inject insulin | Interactive computer game, has seven parts including: 1. paired game familiarize with equipment needed for insulin injection; 2. puzzle game; 3. question and answer game; 4.insulin kit game; 5. painting room; 6.story game; 7.creating a simulated environment for insulin injection | Cognitive (Application) | Scaffolding | Not Mentioned | medical students and residents /Both | Diabetes Mellitus | Insulin Therapy |
| 19. | Diabetes Visu-alizer | To provide the user with skills and knowledge of how blood sugars are affected by food, insulin and activity | Interactive game play, first person visuals and 3D animated. The animation allows the viewer to see the changing status of “blood sugar” over time as an animated visualization in contrast to the more static points | Cognitive (Comprehension) | Not Mentioned | Effective in engaging participants. | Not Mentioned/ Not Mentioned | Type 1 | Insulin Injections |
| Row | Game name         | Aim/s                                                                 | Features                                                                 | Learning Domain(subdomain)          | Learning Theory | Effectiveness                                                                 | Target Audience/gender | Type of Diabetes | Target Aspects |
|-----|-------------------|----------------------------------------------------------------------|--------------------------------------------------------------------------|-------------------------------------|-----------------|-----------------------------------------------------------------------------|-------------------------|-----------------|-----------------|
| 20  | Wii Fit Plus      | To improve HbA1c as well as weight, cardiometabolic risk factors, physical activity and quality of life in T2DM patients. | Nintendos exergame and Combination of physical activity and video games. | Cognitive (Application)             | Not Mentioned   | Improving PA, glucometabolic control and quality of life in T2DM patients | Both                    | T2DM            | Self-Management |
| 21  | Cyber-cycle       | To improve physical activity                                           | Stationary bike with a video screen that displays interactive virtual game components. | Cognitive (Knowledge)               | Cognitive       | Older adults with and without diabetes were able to use cyber-cycles successfully. | Patients, 50–75 years old /Both | Type 2          | Physical Activity |
| 22  | Dance Dance Revolution | To improve physical activity                                           | Exer-game with the potential for a workout progression from basic to advanced physical challenges | Cognitive (Application)             | Flow theory     | Effective in meeting vigorous PA requirements                               | Adults, 60 to 88 years old / Both | Diabetes Mellitus | Physical Activity |
| 23  | SNAP system       | To deliver an entertaining gaming experience with a long-term solution to physical inactivity | SNAP system, inspired primarily by the novelty introduced by Nintendo Wii and its inability to enforce full-body activity. | Cognitive (Application)             | Flow            | Providing the added benefit of greater access to lots of user pose data instead of SNAP system. | Adult, 18-53 years old / Both | Not Mentioned   | Physical Activity |
| 24  | Balance           | To address the target group of teenagers and to integrate the self-management process with its challenges and dangers in the overall gameplay | Jump’n’Run game. The goal is to free sb who were captured by strangers. Should control blood sugar level by eating food and taking insulin. | Cognitive (Application)             | Social learning | Yielding higher game enjoyment than the implicit version.                   | Adult, 18-27 and 49-73 years old /Both | Not Mentioned   | Physical Activity |
| 25  | Didget            | To assess the performance and acceptability of a blood glucose meter in type 1 diabetes | based on the CONTOUR® blood glucose meter that connects to Nintendo game systems, including Nintendo DS and Nintendo DS Lite | Cognitive (Application)             | Not Mentioned   | The Didget system was precise and clinically accurate in the hands of pediatric subjects. | Patients, 11-16 years old /Both | Type 1          | Self-Management  |
| 26  | Escape From Diab | To promote and manage energy                                            | Nine-level action-adventure video game and third-person perspective.     | Cognitive (Application)             | Social-cognitive, Self-Determination | Effective at achieving change in both diet and PA.                          | Participants, 5–24 years old /Both | Type 1          | Treatment       |
## Table 1 Ctd

| Row | Game name | Aim/s | Features | Learning Domain/ subdomain | Learning Theory | Effectiveness | Target Audience/ gender | Type of Diabetes | Target Aspects |
|-----|-----------|-------|----------|-----------------------------|------------------|--------------|-------------------------|------------------|---------------|
| 27. | Hangman   | To improve nutritional goals embedded within the game | Classic guessing game. Having six guesses to estimate the calories or carbohydrates in a given food. | Cognitive (Knowledge) | Tailoring, scaffolding | Not Mentioned | middle school youth /Both | Type 2 | Nutrition and Physical Activity |
| 28. | QuizShow  | To improve nutritional goals embedded within the game | Answering nutrition questions. The gameplay models in Hangman and QuizShow both reinforce nutritional estimation skills while playing a familiar game. | Cognitive (Application) | Tailoring, scaffolding | Not Mentioned | Not Mentioned | Both | Nutrition |
| 29. | Countdown | To improve nutritional goals embedded within the game | Focuses on food comparison skills and receives more points for faster correct responses | Cognitive (Application) | Tailoring, scaffolding | Not Mentioned | Not Mentioned | Both | Nutrition |
| 30. | Nanoswarm | To educate about energy balance | First-person perspective uses live actors and blue screen technology. The player participates in behavior change components embedded in gameplay. | Cognitive (Knowledge) | Social Cognitive, self-determination | Not Mentioned | Both | Nutrition |
| 31. | INSULOT   | To encourage, motivate, and boost the confidence of type 1 diabetic patient and to teach the relationships among plasma glucose level, food and insulin dosage | Three-window slot machine and uses algorithms to simulate postprandial glucose levels. It is a Java 2 Micro Edition application. The application can run as a stand-alone and also be integrated into a World Wide Web environment. | Cognitive (Knowledge) | Cognitive | Patients thought that game recommended to other type 1 diabetic patients. Its usability was highly scored | Youth from multiple ethnic groups, 9-11 years old /Both | Type 2 | Energy Balance |
| 32. | Tamagoya  | To understand general idea regarding relationships among plasma glucose, insulin prescription, food taking and exercise. | PC game, should choose one of the following actions: providing food, insulin and exercise. | Cognitive (Application) | Not Mentioned | Balance between entertainment and learning is a critical factor in developing attractive and effective learning tools. | Patients, 12-24 years of age /Both | Type 1 | Nutrition |
| Row | Game name | Aim/s | Features | Learning Domain(subdomain) | Learning Theory | effectiveness | Target Audience/gender | Type of Diabetes | Target Aspects |
|-----|------------|-------|----------|---------------------------|----------------|--------------|----------------------|-----------------|---------------|
| 33. | Tantei     | To understand general idea regarding relationships among plasma glucose, insulin prescription, food taking and exercise. | Type 1 diabetes player is detective who chases a criminal in game. The right food and insulin based on plasma glucose should be finding on the way to chase criminal. | Cognitive (Application) | Not Mentioned | Balance between entertainment and learning is a critical factor in developing attractive and effective learning tools. | Patients /Both | Type 1 | Nutrition, Physical Activity and plasma glucose level |
| 34. | Magic Toom | To understand general idea regarding relationships among plasma glucose, insulin prescription, food taking and exercise. | Type 1 diabetes player is detective who chases a criminal in game. The right food and insulin based on plasma glucose should be finding on the way to chase criminal. | Cognitive (Application) | Not Mentioned | Balance between entertainment and learning is a critical factor in developing attractive and effective learning tools. | Patients /Both | Type 1 | Nutrition, Physical Activity and plasma glucose level |
| 35. | Not mentioned | To focus on food preferences on activity preferences and patterns | The 41/451/2-inch cards were developed and included a range of foods and activities that were consumed and engaged. Attempts were made to match the various pictures of foods with regard to attractiveness a video game with 24 levels of play take place in different place and each level becomes increasingly more difficult to complete. The characters must save their camp from rats and mice that have scattered the camp's food and diabetes supplies. Players must also help their character monitor blood glucose, take appropriate amounts of insulin, review a diabetes logbook, and find foods containing the right number of food exchanges according to the meal plan. | Cognitive (Application) | Not Mentioned | The card-sorting tasks are useful tools for assessing food and activity preferences and patterns in girls. | Patients /Both | Type 1 | Nutrition, Physical Activity and plasma glucose level |
| 36. | Packy & Marion | To improve a young person's self-confidence, ability, and motivation to undertake the rigorous self-care necessary to control insulin-dependent diabetes. | To improve a young person's self-confidence, ability, and motivation to undertake the rigorous self-care necessary to control insulin-dependent diabetes. | Cognitive (Application) | Cognitive | Improving communication between parents and children about diabetes. Positive health-related behavior change, compared to the control group. Their self-efficacy for diabetes self-care improved. | African American School girl, 8-10 years old /Girl | Not Mentioned | Nutrition and Physical Activity |
| 37. | Activity Activity | To Teach adolescents strategies for recognizing and balancing variations in Physical activity with food or insulin | To Teach adolescents strategies for recognizing and balancing variations in Physical activity with food or insulin | Cognitive (Knowledge) | Not Mentioned | Enthusiasm and participation rates were impressively high. Learning appeared to take place because the pace and sophistication of the game increased substantially with each succeeding round of play. | Patients, 8 - 16 years old /Both | Type 1 | Self-Care |
| Row | Game name                  | Aim/s                                                                 | Features                                                                 | Learning Domain(subdomain) | Learning Theory | Effectiveness | Target Audience/gender | Type of Diabetes | Target Aspects                  |
|-----|----------------------------|----------------------------------------------------------------------|--------------------------------------------------------------------------|-----------------------------|----------------|--------------|------------------------|----------------|-------------------------------|
| 38. | Tic-Tac-Diabetes           | To stimulate participation in the learning process.                   | 4 x 4-foot game board and wooden X’s and O’s that could be hung on hooks in each square were constructed. Nine categories of questions were created for each of the tic-tac-toe squares. | Cognitive (Knowledge)      | Not Mentioned | Not Mentioned | Youth, 9 - 15 years old /Both | Not Mentioned       | Physical Activity              |
| 39. | What’s wrong with This Pic-ture? | To teach and heighten participants’ awareness of their own misconceptions diabetic diet | Pictures of each of the different foods from each exchange list were arranged on cards, with one of the foods being inappropriately Placed within the food group. The participants were given answer sheets to record their individual responses. | Cognitive (Knowledge)      | Not Mentioned | Not Mentioned | Not Mentioned           | Not Mentioned       | Hyperglycemia-Medications Hygiene and Foot Care-Blood Glucose Monitoring |
| 40. | Can You Guess Your Blood Sugar? | To assist staff in becoming familiar with the different types of home blood glucose monitors | The game begins with an explanation and demonstration of blood glucose monitoring equipment. During the demonstration, each participant’s blood glucose level was monitored. participants were asked to guess their blood glucose levels and to determine the accuracy of their guess | Cognitive (Application)    | Not Mentioned | Not Mentioned | Not Mentioned           | Not Mentioned       | Nutrition                      |
| 41. | Betakid                    | To provide an opportunity for diabetic children to practice and evaluate skills in food and insulin dose selection | the simulation begins with a graphic of Betakid awakened by his alarm clock. Additional events in Betakid’s day follow a typical adolescent’s Activities: meals, classes at school, exercise, and after-school activities. A multiple-choice format for food, insulin, and exercise decisions was used. The current blood glucose level is a factor in determining if a decision is correct. | Cognitive (Knowledge)      | Not Mentioned | Not Mentioned | Not Mentioned           | Diabetes Mellitus   | Nutrition and Insulin Dose     |
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Conflict of Interests

The authors declare that they have no competing interests.

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