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A systematized review on diabetes gamification

Shadi Asadzandi[1], Shahram Sedghi*[1,2], Shoaleh Bigdeli[3], Mahnaz Sanjari[4,5]

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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. Professor, Health Management and Economics Research Center, Iran University of Medical Sciences, Tehran, Iran; Librarianship and Medical Information Science, Iran University of Medical Sciences, Tehran, Iran.

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

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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 lower the risk of developing diabetes (6) and mainly increasing knowledge, awareness and attitude, acquiring necessary skills, enhancing coping with the disease, performing the required care, accelerating improvement and recovery, and minimizing the complications

Corresponding author: Dr Shahram Sedghi, sedghi.s@iums.ac.ir

1. Department of Librarianship and Medical Information Science School of Health Management and Information Sciences, Iran University of Medical Sciences, Tehran, Iran
2. Health Management and Economics Research Center, Iran University of Medical Sciences, Tehran, Iran
3. Center for Educational Research in Medical Sciences (CERMS), Department of Medical Education, School of Medicine, Iran University of Medical Sciences, Tehran, Iran
4. Diabetes Research Center, Endocrinology and Metabolism Clinical Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran
5. Endocrinology and Metabolism Research Center, Endocrinology and Metabolism Clinical Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran

↑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.

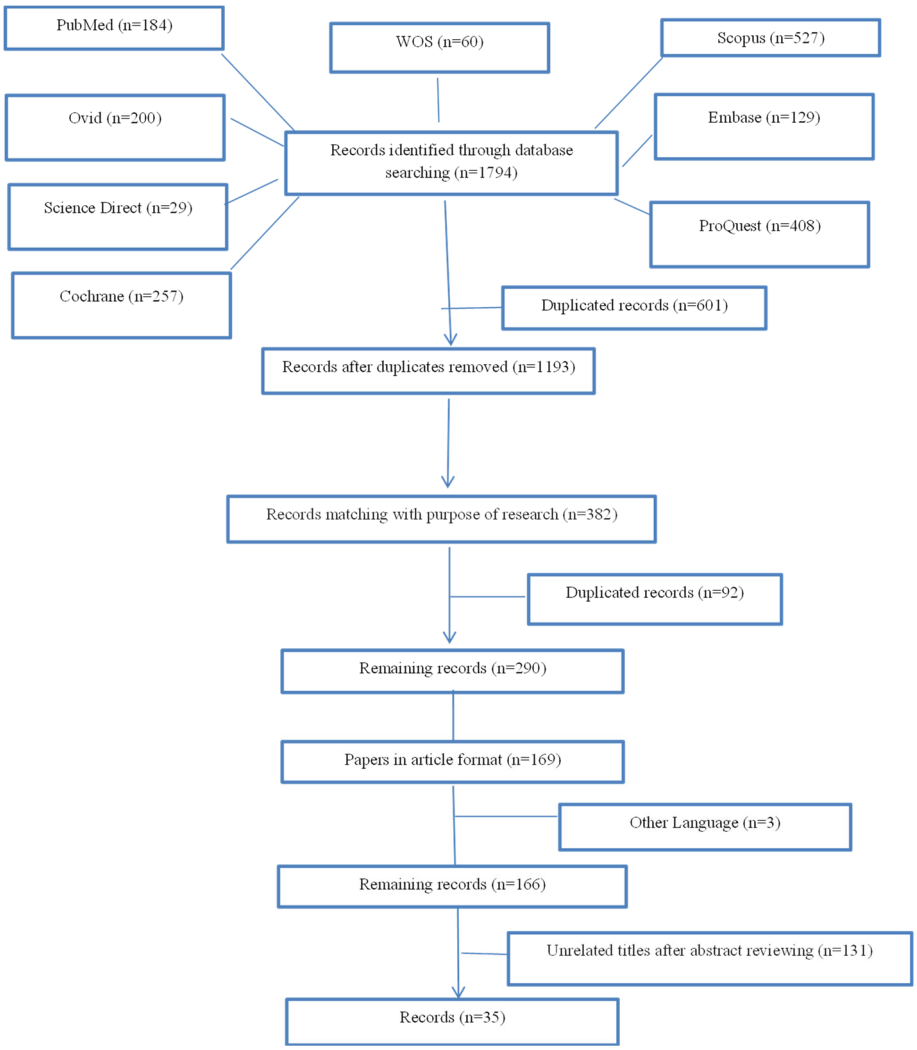
is absolutely necessary (7-10). Today, educating people with emerging technological advances and multimedia encourages them to learn and develop an understanding of the disease, and adapt to the new information (11). Therefore, considering the high prevalence of diabetes in the world and its unwanted 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,



Flowchart 1. Assessment and selection of papers in the field of diabetes gamification

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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.

Table 1. Bibliographic information of the retrieved articles in the field of diabetes gamification

Row	First Authors	Title	Journal	Year
1.	Klaassen, R	Design and Evaluation of a Pervasive Coaching and Gamification Platform for Young Diabetes Patients	Sensors	2018
2.	Diehl La	InsuOnline, an Electronic Game for Medical Education on Insulin Therapy: a Randomized Controlled Trial With Primary Care Physicians	Journal of Medical Internet Research	2017
3.	Kerfoot, Bp	a Team-Based Online Game Improves Blood Glucose Control in Veterans with Type 2 Diabetes: a Randomized Controlled Trial	Diabetes Care	2017
4.	CalleBustos, A	An Augmented Reality Game to Support Therapeutic Education for Children with Diabetes	Plos One	2017
5.	Blanson Henkemans, O	Design And Evaluation of a Personal Robot Playing a Self-Management Education Game with Children with Diabetes Type 1	International Journal of Human-Computer Studies	2017
6.	Eukel,H; Frenzel, J	Educational Gaming for Pharmacy Students – Design and Evaluation of a Diabetes-Themed Escape Room	American Journal of Pharmaceutical Education	2017
7.	Brinkmann, Ch	Effects of Cycling and Exergaming On Neurotrophic Factors in Elderly Type 2 Diabetic Men – a Preliminary Investigation	Experimental and Clinical Endocrinology and Diabetes	2017
8.	Höchsmann, Ch	Mobile Exergaming for Health—Effects of a Serious Game Application For Smartphones on Physical Activity and Exercise Adherence in Type 2 Diabetes Mellitus—Study Protocol for a Randomized Controlled Trial	Trials	2017
9.	Ledoux,T	an Educational Video Game for Nutrition Of Young People: Theory and Design	Simul Gaming	2016
10.	Maas AH	Concept Development of The Eindhoven Diabetes Education Simulator Project	Games for Health Journal: Research, Development, and Clinical Application	2016
11.	Baghaei, N	Diabetic Mario: Designing and Evaluating Mobile Games for Diabetes Education	Games for Health Journal: Research, Development, and Clinical Applications	2016
12.	Joubert, M	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	Diabetes Technology & Therapeutics	2016
13.	Jingjing, W	Acceptability and Applicability of an American Health Videogame with Story for Childhood Obesity Prevention Among Hong Kong Chinese Children Research	Games for Health Journal: Research, Development, and Clinical Applications	2015

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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-Hanley, 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 f 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 (Didget®) 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

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-

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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—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**,** soundscape, 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

cording to the title or game features, some games are considered as educational game such as the diabetes escape room, Escape from DIAB, Nanoswarm and Packy & Marlon 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

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Table 2. Ctd

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	Diabetes specialties and nurses	Japan
31.	Development and implementation of a visual card sorting technique for assessing food and activity preferences and patterns in African American girls	Not mentioned	Not mentioned	USA
32.	Educational video game for juvenile diabetes: results of a controlled trial	Packy & Marlon	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	Not mentioned
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

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 (14 papers) 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

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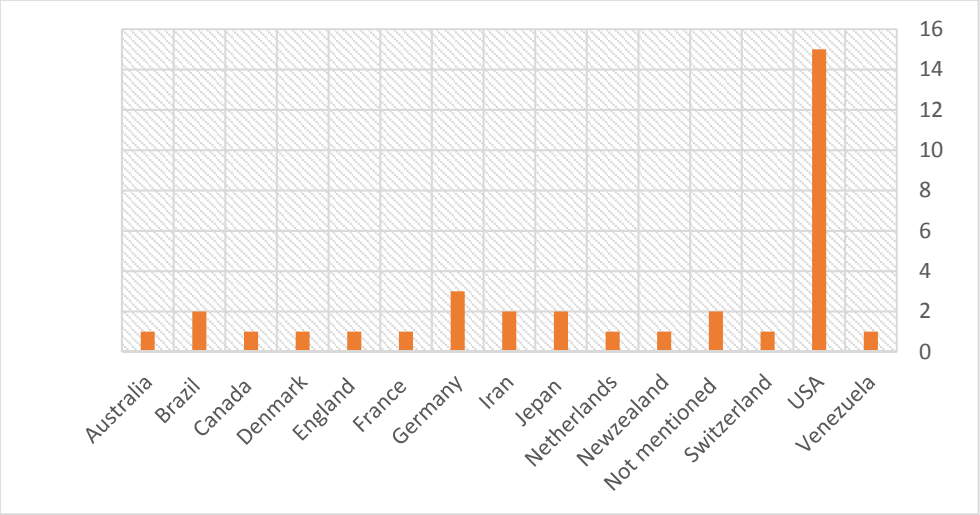

Fig. 1. Distribution of diabetes gamification in terms of country of origin

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.

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Table 3. Classification of diabetes gamification according to the learning domain, underpinning learning theories, game effectiveness and Characteristics of the participants

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 A_{1c} (HbA_{1c}) 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, farinaceous 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

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Table 3. Ctd

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 interprofessional 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 cardiorespiratory fitness in type 2 diabetes	Nintendo's exergame, Combination of physical activity and video games	Cognitive (Evaluation)	Not Mentioned	Improve cardiorespiratory 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.	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	Improvement of insulin and carbohydrate quantification in children with type 1 diabetes	Children, 9–13 years old/ Both	Both	Education Diabetic

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Table 3. Ctd

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 G4H 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-Tavana	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 V̇O2peak in elderly type 2 diabetic patients	Nintendo exergame, with Combination of physical activity and video games	Cognitive (Evaluation)	Not Mentioned	Improving cardiorespiratory fitness and glucose metabolism.	Undergraduate medical students and Internal Medicine residents/ 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, 45 to 70 years old/ Both	type 2	Physical Activity
18.	Koodak-e-Tavana	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 Visualizer	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 Mrntionrd	Type 1	Insulin Injections

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Table 3. Ctd

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	Not Mentioned/ Not Mentioned	Both	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

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Table 3. 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	effective medium for promoting youth diabetes and obesity prevention	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, 9-11year-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

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Table 3. Ctd

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 4 1⁄4 5 1⁄2-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	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 & Marlon	To improve a young person's self-confidence, ability, and motivation to undertake the rigorous self-care necessary to control insulin-dependent diabetes.	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)	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	4x6 index cards. Each index card depicts physical activity and duration, an insulin adjustment and an amount of a particular food with the exchange and carbohydrate equivalents. The game was played in small groups of 3 to 4 teams of campers during one of their four regularly scheduled, 45-minute education sessions.	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

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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 Picture?	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 To Know the difficulties some individuals with diabetes encounter when learning to perform self-testing	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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