Digital games in medical education: Key terms, concepts, and definitions

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Abstract
Background: Game-based education is fast becoming a key instrument in medical education.
Method: In this study, papers related to games were filtered and limited to full-text peer-reviewed published in English.
Results: To the best of researchers' knowledge, the concepts used in the literature are varied and distinct, and the literature is not conclusive on the definition of educational games for medical education.
Conclusion: This paper attempts to classify terms, concepts and definitions common to gamification in medical education.

Keywords: Game, Simulation Game, Medical Education

Introduction

Games are as old as human beings; however, the history of educational games was first detected at the time when Socrates and Plato used a kind of verbal play in their "dialogues". In the 19th century, Froebel integrated "learning," "game" and "play"; and, in the 1990s, digital games were developed further and became dramatically widespread among the youth, resulting in a cohort of incoming students accustomed to digital game plays (1).

A considerable amount of literature has been published on digital games, and a number of researchers have sought to define the key concepts and essential elements (2,3). There are five attributes encapsulating the concept of educational games: player or players, conflicts, rules, predetermined goal of the game, artificial nature of games (4), and since the focus of this review study is on educational games, the pedagogical nature of the game provides a sixth attribute.

Integration of digital educational games into existing medical education context is a challenge and a current focus of attention in studies for teachers, learners and cli-

nicians in settings of medical education. Some studies have emphasized the positive influence of games over traditional teaching methods for educational purposes (5, 6). On the other hand, several authors have claimed that students with diverse learning styles (e.g. visual and aural, read/write, and kinesthetic) can benefit from educational games (7) provided that individual personal characteristics be considered in the instructional design of the games.

In medical education, digital games have been presented in different digital formats such as simulations, virtual environments, social and cooperative plays and alternative reality games (5-10); however, simulations are different from games in nature, as are virtual environments. Therefore, in this study, we included simulation games and the virtual environments containing a digital game. As medical professions are practice-based, a majority of game-based programs focus on procedural skills (e.g. surgery, laparoscopy) that can improve patient safety, help limit burnout and fulfill the promise of competency-based education (11). The current technology of digital games has

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↑*What is "already known" in this topic:*
• Educational games in medical education are growing fast,
• The literature is not conclusive on the definition of educational games in medical education.

→*What this article adds:*
• The pedagogical nature of the game is a sixth attribute encapsulating the concept of educational games
• Characteristics of the learners must be considered in medical education game design
• Educational games in medical education can be classified according to cognitive, psychomotor, and affective learning domains.

the potential to provide virtual experiences in a more cost-effective manner, and learners can be exposed to diverse case scenarios enabling them to create and evaluate both positive and negative outcomes of clinical procedures (12). In addition, this technology provides a safe environment (13, 14) for learners to gain skills and self-confidence without being stressed about making the real-world judgments, as well as ensuring patients' safety. Unlike real-world practice which might endanger patients' safety, the educational game technology provides a safe environment in which learners can practice and gain skills and experiences self-confidently without threats of the real-world.

Although extensive research has been carried out on the application of digital games in medical education, to the best of researchers' knowledge, there are few studies which adequately cover the terms, and concepts, and to the best of researchers' knowledge none of them provides a sound classification which is based on cognitive, psychomotor and attitude domains of learning.

This review study provides an overview of terms, concepts, and definitions used as efficient educational elements of digital games in medical education. Elaborating these concepts in all disciplines of medical education is beyond the scope of this paper, and we will only focus on terms and concepts used in medicine, nursing, pharmacy, and dentistry.

Methods

This review study was conducted from September to December 2015 via SFU library, CINAHL Complete, Cochrane Library (Cochrane CENTRAL and Cochrane Reviews), EBSCOhost, Elsevier Science Direct, ERIC, PsycINFO, PsycARTICLES, PubMed, PubMed Central (PMC), PubMed/MEDLINE, with Search terms (AND, OR, NOT) and keywords: game, gamified, gamification, computer game, digital game, electronic game, video game, systematic review, meta-analysis, meta-analysis, health professions, medical, nursing, pharmacy, dentistry, education in peer-reviewed journal articles to find all digital games related to medical education disciplines of medicine, nursing, pharmacy and dentistry.

Inclusion and exclusion criteria

Papers related to games were filtered and limited to full-text peer-reviewed papers published in English in 2010-2015. The papers were included if addressing digital games in medical education (disciplines of medicine, nursing, pharmacy and dentistry), and if students were participants of the study. The aforementioned disciplines were selected to narrow the scope of the paper and to explore the topic in these fields more precisely.

The articles were excluded if the topics were not related to medical education, were not available in full text, the participants were patients, teachers and/or staff only, the participants composed of residency students and/or medical professionals (e.g., surgeons, specialists) only.

Moreover, studies addressing blogs, discussion boards, podcasts, videos and video-conferencing, and non-digital games were excluded. Finally, studies on apps for smartphones, tablets, portable music players, and topics of patient management, patient education, teacher, and staff education were excluded too.

Titles and abstracts, resulting from the initial online search with selected MeSH and free text terms related to digital educational games, were screened for relevance and eligibility for full-text retrieval. Additional articles were searched through citation by manual checking of the reference sections of the sourced articles. The full texts recognized eligible were also screened, and the researchers resolved their disagreements by discussion if they were any. Finally, the selected relevant articles retrieved were those that focused on the use of specific educational games for learning in four disciplines of medicine, nursing, pharmacy, and dentistry.

Results

Postmodern generation of game players

According to the findings of the present study, diverse terminology is used to define current generation of medical education students as native speakers of digital educational games. They are mainly divided into seven categories defining highly active participants who spend countless hours on playing digital games individually or in groups. They seek enjoyment and power to use technology limitlessly (15) and in a timelessly manner. This multitask generation demands something more than "textbooks" and non-interactive "lectures" for learning (16) (Table1).

Digital games and medical education

A digital educational game for specific purposes of medical education is an electronic game involving interaction of medical practitioners and students with a user interface in an offline and/or online mode reference. Popular electronic devices used by medical professionals include but not limited to desktop computers, laptops, tablets, ipads, ipods, and smartphones. The findings of the present study showed that there is no clear distinction between "game", "simulation", and "simulated game", they are used interchangeably in the literature, and there is a relative overlap in definitions. Games and simulations bear common elements of rules and regulations, mechanics, engagement, collaboration and interactivity with highthinking and mental engagement. However, in practice, games enjoy elements of competition, fun, and entertainment while simulations are more serious and similar to real life situations and usually lack these features. Current terms and concepts used are presented in (Table2).

Table 1. Terminology to define current generation of health professions students

Term	Citation	Definition
''Homozappien''	[15]	Postmodern generation of learners
	[12]	Current aspiring medical students who read less and are more comfortable with electronic interactivity
Millennials	[7, 17]	Students born in or after 1982 who expect instantaneous responses and are multitask prefer active, engaging activities rather than traditional teacher-centered activities, prefer teamwork and social networking, excitement, entertainment and technology
	[18]	Generation of learners with ubiquitous access to information technology throughout their education
	[19]	Net Generation
Digital Native		"Native speakers" of the digital language of computers, video games and the Internet
Digital Immigrant	[20]	Those not born into the digital world but have at some point in their life access to the new technology
N-[for Net]-gen		"New" students of today
D-[for Digital]-gen		Those born since 1982
	[21]	Born between 1982 -1991, more comfortable with information and communications technology environments rich in audio-visual multimedia, prefer first person, active, engaging self-directed activities rather than traditional teacher-centered activities, interested in excitement, fun and entertainment, expect immediate responses and are achievement orientated, prefer a clear learning outcome rather than ambiguity, spend many hours playing computer games, prefer collaborative teamwork and social networking, like to talk about what they are doing, especially to other members of their peer group
Net generation	[7,17, 18, 19,22]	
Generation Y	[19]	Net generation

Moreover, in dentistry, simulations, robotics and haptic technology focusing on psychomotor skills (8) are of major concern, and it appears that simulation is more serious and similar to real life experiences, and elements of fun and entertainment are of less importance.

There are at least 16 categories of digital games, available for educational and commercial purposes, some of which can be used for medical professions education (Table3). Minesweeper as a puzzle game, Grey's anatomy as a TV show format and scratch offs are some of the examples.

Digital games of medical professions improving cog-

Table 2. The terminology of games for educational purposes

Terms	Definition	Citation
Game	An outcome-oriented activity that proceeds according to a set of rules and often involves focused decision-making	[23]
	An activity with a competitive element, the aim of which was to promote learning and the retention of educational material	[14]
Gaming	The use of game design elements to increase user engagement	[24]
Gamification	The process of applying gaming mechanics, frameworks and principles (competition, rewards, enjoyment) to a nongame-related endeavor (situations, contexts, and scenarios, e.g. workplace collaboration, marketing, education, military, and medical services) to increase user engagement.	[5, 11, 18, 25, 26, 27]
Game resources	Workplace pictures, animations or other visual assets, sounds, videos, etc.	[27]
Educational game	A competitive experiential learning activity with precise rules and various degrees of chance, in which players compete through knowledge and skill in an attempt to reach a specified goal	[7, 9, 10, 13, 28,29]
	A competitive activity with a prescribed setting constrained by rules and procedures, stimulate higher thinking such as analysis, synthesis, and evaluation, make the learning process fun and exciting and reduces stress and anxiety, which in turn may increase retention	[9]
Game-based learning	Attempts to situate learners as players and provide learning activities within a recognizable game delivery model	
Game-informed learning	Suggests that it is possible to make teaching practices more game-like by applying the principals of gameplay without necessarily having to be committed to developing a game to produce the same compelling, immersive learning experiences	[30]

Cntd Table 2

Free to play games	F2P software space are ubiquitous and free for users access. Meanwhile developers use data for insights on how to increase player acquisition and engagement	[18]
Video game	A mental contest with a goal or objective played on a digital device according to rules that determine what a player can and cannot do inside the game world	[31]
Serious games	Interactive digital technologies whose primary purpose is to educate rather than entertain; include games and simulations that explore interpersonal development, diplomacy, organization, health, education, management, and leadership	[31, 32]
Serious gaming	Educational or virtual gaming as ''any piece of software that merges a non-entertaining purpose (serious) with a video game structure (game).''	[33, 34]
Serious educational game (SEGs)	Games developed primarily for educational purposes	[31]
Simulation	A sort of "concentrated reality" that offers opportunities to rehearse life-saving skills and knowledge as often as necessary	[21]
	Another category of ''serious games'', tend to be more realistic, range from simple, case study video scenarios to complex computer simulations that interface with lifelike manikins have different forms of role-playing, computer-based, and manikin-based	[33]
	Practical exercises that lack the competitive elements of games	[14]
Simulation game	Any computerized game whose chief mission is not entertainment and all entertainment games which can be reapplied to a different mission other than entertainment	[35]
Simulation key elements	Feedback, repetitive practice, curriculum integration, range of difficult, multiple learning strategies, controlled environment, individualized learning, defined learning objectives	[24, 30]
Advanced Navigational Simulation (Global Positioning-Type Systems)	A surgical computerized modality based on the synchronization of the intraoperative position of the instruments in which the surgical instruments are accurately tracked and targeted to a preplanned location within the surgical field with the imaging of the patient's anatomy previously obtained by computed tomography (CT) or magnetic resonance imaging (MRI)	[8]
Virtual reality	The recreation of environments or objects as a complex, computer-generated image capable of encompassing most medical issues and can be used by all health care disciplines	[21]
	Creates virtual worlds using mathematical models and computer programs, allowing users to move in the created virtual world in a way similar to real life	[8]
Second Life	A three-dimensional technology that provides simulation- based virtual settings that provides a way to combine new simulation technologies with role-plays to enhance instruction	
Robotics	A technology focused on more realistic mannequins able to simulate movements and verbal expression of emotions like pain that provides an opportunity for instructors to remote control them to teach the students to anticipate patient's behavior while working	[8]
Haptic technology	A technology that provides users with the ability to interact with virtual objects within the virtual environment via feel and touch	

nitive, psychomotor and affective abilities are presented in Table 4. Most of these games improve knowledge acquisition and cognitive abilities and a few of them target attitudes. It seems that targeting educational objectives at cognitive level is more achievable than psychomotor and affective educational levels. Moreover, characteristics of undergraduate students (e.g. medical) and their educational needs are different from postgraduate students (e.g. medical residents), graduates and specialists. In this regard, application of games designed for a specific target group may not deem feasible for another audience; for example, abcdeSIM, which originally was developed for medical residents was counterproductive for novice learners (28)). Therefore, it could be inferred that characteristics of each target group should be considered separately in designing an educational game.

Table 3. Types of digital educational games for Medical Education

Types of Games	Citations	Game Name and Designer (Examples retrieved from Wikipedia.org)
Card games	[13, 34, 36]	*Magic: The Gathering* (Richard Garfield)
Board games	[13, 34]	*Ticket to ride* (Alan R. Moon)
Simulation	[13]	*The Sims Online* (William Ralph Wright)
	[13, 22]	*Final Fantasy XI* (Hiromichi Tanaka)
Role-playing	[37]	*Geriatric Medication Game*, Saint Louis College of Pharmacy
Frame games	[36]	*Portal* (Valve Corporation)
Puzzles	[22, 36]	*Minesweeper* (Curt Johnson)

Cntd Table 3

Cross-words	[36]	*Digital Cross Words* (USA today)
TV show format	[13]	*Grey's Anatomy* (Shonda Rhimes)
Virtual learning 3D platform	[21]	*Second Life* (Linden lab)
Game show		*The Chamber* (Rick Schwartz)
	[34]	
Slide presentation		*Concentration 9* (Lora O'Neil)
Multi media		*Magnet Mania Scratch off* (TCD Communications, NY)
Strategy game	[22]	*Dungeons and Dragons* (Gary Gygax and Dave Arneson)
3D First person shooter game	[22, 38]	*Half-Life* (Valve Corporation)
2D non–first-person shooter game	[38]	*Chessmaster* (Ubisoft Romania)
Arcade games	[22]	*Periscope* (David Rosen)

Table 4. Classification of digital educational games according to cognitive, psychomotor, and affective learning domains: Examples

Game Name	Target Discipline	Learning Domain	Impact	Citation (s)
Abcdesim (high fidelity simulation game)	Medical Students (4th-year)	Cognitive	Complex cognitive emergency care skills of medical students were not improved	
			No improvement on skills and performance	[28]
			More motivation and cognitive involvement	
			Motivation and cognitive involvement were unrelated to learning outcomes	
	Originally developed for residents		Physical fidelity (tools and sounds in the game) with too many details created cognitive overload	
			Counter -productive for novice learners	
Septris (Game)	Medicine	Knowledge Skills Attitude	Positive effect in al l four areas of dissemination, learner's knowledge related to sepsis, learners' self-reported knowledge, skills, and attitudes related to sepsis, and learner satisfaction with the game	[25]
E-baby serious game oxygenation of preterm babies	Nursing		Student satisfaction	[32]
			Facilitates teaching and learning process	

Conclusion

This paper was an attempt to provide an informative overview of the elements appearing in studies related to educational games. It was a comprehensive review of the existing literature on educational games with a specific focus on medical education, addressing terminology common to digital educational games,defining current millennial learners, different types of games, and classifi-cation of games on the basis of the cognitive, psychomotor and affective learning domains. Also, to the best of our knowledge, it is the first study which summarizes the major terminology of game players and common terms related to digital educational games of medical education in a comprehensive and concise manner.

Although the study used a comprehensive search strategy, it had a limited scope of review. The findings apply to

Cntd Table 4

Virtual Emergency TeleMedicine (simulation-based game)	Medical Other health care professionals (e.g. Nursing and Paramedics) and Medical Students	Knowledge	Positive results in game interface, feedback, difficulty level, educational value, user engagement, and terminology used in the game	[39] Study participants professionals
Pulse!!	Paramedical	Practical knowledge		[39]
	Medical	Experiential learning	Educational and training tool Helps develop critical thinking and Practical knowledge	[21]
	Nursing	Cognitive Psychomotor	Enhancement of knowledge, psychomotor skills and decision-making Improved performance Confidence increase The potential to improve competence	[24]
	Civilian military students and professionals	Cognitive and psychomotor skills	No result of the efficacy is reported	[38]
GeriatriX	Medical	Knowledge Attitude	A positive change in students attitudes toward elderly adults A considerable improvement in students self-perceived knowledge of important geriatric topics Students moderate to high enjoyment	[40]
Ward (simulation game)	Nursing	Knowledge Practice	A great success in focusing students' sights and skills Knowledge improvement Reinforcement of material learned	[41]
Nursopardy (game)	Nursing	Knowledge	Increased learner confidence to take part in standard-ized exams Positive learning Experience	[7]
Uro-Island	Medicine	Cognitive Attitude	Cognitive learning outcome significantly and effectively higher More positive attitude	[6]
InsuOnline	Primary Care Physicians	Knowledge Attitude		[42]
Medicina	Nursing	Knowledge	A significant improvement for the recognition of words and word forms	[43]
eMedOffice web-based collaborative serious game	Medical	Knowledge Attitude Practice	Positive learning effect Strong collaboration Willingness to learn Fostered competitive cooperation Enhance problem-solving competence An enjoyable learning atmosphere	[35]
Spaced education (SE)	Medical	Knowledge	An effective and well accepted means of teaching core content A reliable and valid method to assess student knowledge Generates deep learning increases knowledge acquisition and retention	[23]
Path to Success and The Path is Right	Medical	Knowledge	Enhanced academic performance	[15]
Complementary e-learning resources			Augmented contextual thinking and reasoning	

some formats sometimes labeled games, role playing, simulations and serious games due to their blurred margins which make the discrimination unlikely. Even though rigorous attempts were made to ensure that this review covered all articles on educational digital games in the disciplines of medicine, nursing, dentistry, and pharmacy, some papers might not have been identified.

Finally, we would suggest that a collaboration of a team consisting of curriculum designers, educational psychologists, cognitive psychologists, educational philosophers and technical game designers for developing educational games in health professions education is strongly recommended.

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Conflict of Interests

The authors declare that they have no competing interests.

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