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Making a serious game (gamification) for generation Z medical students to learn, teach, and assess medical Physiology

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Abstract:

The concept of serious games and gamification in medical education is gaining attention due to its nature of curiosity and to engage the student's attention by simultaneous cultivation of their higher-level thinking without the experience of boredom. Significant differences were reported among the present medical students, generations Y and Z compared to earlier generations. The advancements in serious games for medical education fit well with millennial medical students' learning styles. Till date, there are no scientific research studies available in literature majorly using solo playing gaming experience for medical Physiology teaching, learning, and assessment in medical schools. In this unsystematic (narrative) review, the development and process in gamification for medical Physiology teaching and assessment has been analyzed. Inclusion criteria: list of articles from PubMed, Medline, and Cochrane by means of manual search with the key words include; gamification on Physiology teaching, learning; serious games created/developed for medical Physiology. Exclusion criteria include the articles not involving medical Physiology teaching, gaming app application, card board games, and quiz games. This review explores the difficulties and practical challenges encountered by a medical educator/doctor professional toward the development of solo playing gamified platform. Also further necessitates the user-friendly interface or apps that involve drop and drag options for serious solo playing games development for medical education. Additionally, insists the addition of gamification elements and artificial intelligence tools application as one of the components of curriculum as electives in medical schools for undergraduate and post graduate level. These will pave the way for medical educators to familiarize the gamification designing tools for various serious solo playing games for medical subjects' teaching, learning, and assessment.

Keywords:

Game based learning, generation Z, medical education, serious games, simulation based learning

Introduction

It was predicted way back in 2012 that there will be an advancement in development and the use of simulations and digital games in learning methodologies and assessment over the next several years.[1] The usage of computer and technology in recent decade is integrated in our day-to-day life and it is advancing further every year particularly in the field of medical education. The coronavirus disease 2019 (COVID-19) pandemic restrictions have further provoked the evolution of teaching and learning methodologies among medical schools and advanced the scope to use newer teaching and learning methodology in medical education.[2] The concept of serious games and gamification in medical education to increase the student's attention, facilitate learning, and simultaneously cultivate their critical thinking skills with less boredom

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is gaining attention. Globally the present-day medical students probably belong to Generations Y and Z. Till now, five generations were classified by the year of birth: Traditionalists (1928–1944), Boomers (1945–1965), Generation X (1965–1979), Millennials or Generation Y (1982–1995), and Post-Millennials or Generation Z (after 1995). Similarly, Centennials are children born after 2001 onwards (iGen), children born between 2010 and 2025 will be called as Google kids or Generation Alpha.[3] Currently, the predominant students in the medical curriculum are from Generation Z.[4] The evolution of medical educators and their teaching modalities has already shifted from the traditional method to more recent methods and it is still evolving in order to match the existing generation behavior. Significant differences had been already noted among Generation Z students compared to earlier generations by the educators in medical schools. Generation Z students are considered as authentic digital natives with hypercognitive student profiles than before generation. They are creating pressures for change, and there is a growing competition of universities for global human talent and demand for qualified graduates to do jobs that do not yet exist. Students of Generation Z seem to be tech savvy and the usage of technology and digital gadgets forms an integral part of their life.[3] Their involvement in the same seems to be very intense indeed. The reason could be the fact that the first generation may always had their constant access to internet and social networking since birth.[5] This further alters their view and choice of preference toward learning which involves digital technologies, gamification, and even approaches the educators to customize their learning methodologies that consume less time and greater freedom using technology. The usage of digital modalities and technologies like digital gaming, Google classroom, 3-D printing models, skill-based videos, and mobile-based quiz were already being used due to its greater benefits over customized teaching that includes timing flexibility, asynchronous learning, immediate feedback and review from the educator.[6] It is to be noted that current generation students have short attention spans[7] and may struggle to manage downtime.[8]

Generation Z in medical education and the role of gamification in learning: Generation Z is commonly referred as digital natives[9,10] due to their significant exposure, knowledge, and extensive familiarization to the digital languages of computers, internet, video games, information technology skills compared to previous generations.[11] In medical education, role plays, mobile applications, virtual patient simulations, and gamified training platforms for both preclinical and clinical training had been developed over the past decades,[12] and it seems to be effective. It is evident that the majority of students attending medical school these days are reported to have high degree of technological literacy and desirous for a diverse educational experience.[13] The new media involvement which includes computer, video games (both casual and serious types), virtual reality environments, social networks, web sites, mobile devices, blogs, and podcasts[14] is gaining importance in the medical education teaching and demonstration. It is indeed upon the educators to show academic leadership and use advanced teaching methods to engage the medical students to become doctors with better competencies and skills.[15] The involvement of serious games in education fits well with millennial medical students' learning styles. A study regarding the same principles was conducted among the 217 medical students from two American universities using cross-sectional survey and found that 98% medical students liked the idea of using technology to enhance healthcare education (98%) and 80% believed that video games can have educational value.[16,17] However, there is no scientific original research or studies in the literature on medical students using solo playing games to teach, learn, and assess the discipline of Physiology in medical schools. So far only one article has been published by Moro *et al*.[18] utilizing the serious games for the combined Physiology and Anatomy learning and revision for the Biomedical sciences at Bond University on the Gold Coast, Australia. The game was developed for the health sciences and medicine program and was made freely available on the steam platform under the name of "The King's Request: Physiology and Anatomy Revision." Table 1 lists the published articles that involve gamification for teaching and learning Physiology.

Till date, there is no scientific original research or studies available in literature on medical students using solo playing games for teaching, learning, and assessment of Physiology in medical schools especially in the Indian subcontinent. The main purpose of this review is to address the above lacunae as well as the practical challenges encountered by the medical educator/doctor toward the development and application of gamification/solo playing gamified platform for medical Physiology teaching and assessment is subjective and require adequate passion, technical, gaming, and coding experience. In this review, we also have tried to explore the various resources and the expertise essential for the development of gamification in medical education along with the challenges faced.

Materials and Methods

The purpose of the unsystematic (narrative) review is to discuss the perception of medical educator challenges on designing the serious gaming platform for medical Physiology learning and teaching. Exploring briefly the serious game development software to design the games

Table 1: List of the published articles that involves gamification for teaching and learning physiology

Article	Title	Objective	conclusion	References
Original	Utilizing serious games for Physiology and Anatomy learning and revision	Recording the response and the perception of the biomedical science students to revise Anatomy and Physiology using in-house created learning game, The King's Request: Anatomy and Physiology Revision Game by Dr. Christian Moro	Express the experience in gamification in learning as highly engaging and self-directed	[18]
Original	Educational card games for understanding gastrointestinal Physiology	Development of Go GI and GI Rummy card games to support the students for the Gastrointentinal (GI) Physiology understanding and learning	This novel approach enhanced the students understanding, application a nd synthesis of GI Physiology	[38]
original	The PEGASUS games: physical exam, gross Anatomy, Physiology and Ultrasound games for preclinical medical education	Assesment of created gamification integrating ultrasound model along with other subjects anatomy, physiology, physical examination, and radiology for preclinical medical students compared with traditional didactic education	Gamification integration for preclinical medical students is effective for learning than a traditional learning model.	[39]
Original	Interactive computer-assisted instruction in acid-base physiology for mobile computer platforms	Learning modules were developed, each with 20 screens of information to learn acid base Physiology,	It was reported as interactive by the students and seems like well received.	[37]
Original	Computer game-based and traditional learning method: A comparison regarding students' knowledge retention	Comparing the traditional learning method to computer game based learning method to teach the head and neck Anatomy and Physiology	In general game based learning seems to be effective for short term gain and traditional learning method is both short and long term.	[40]
Original	Oral Communications: Teaching physiology using a Gamified Flipped Classroom model.	Do gamified flipped class room could be an effective teaching and learning methodology?	Students reported that gamification in flipped class room is effective	[41]
Original	Low-Tech Gamification and TBL Strategies to Teach Physiolgy	Compared the usage of interactive game and team based learning with no technology to understand the structure and function of autonomic nervous system (ANS) among 1st year Pharmacy students	The method is found to be effective	[42]

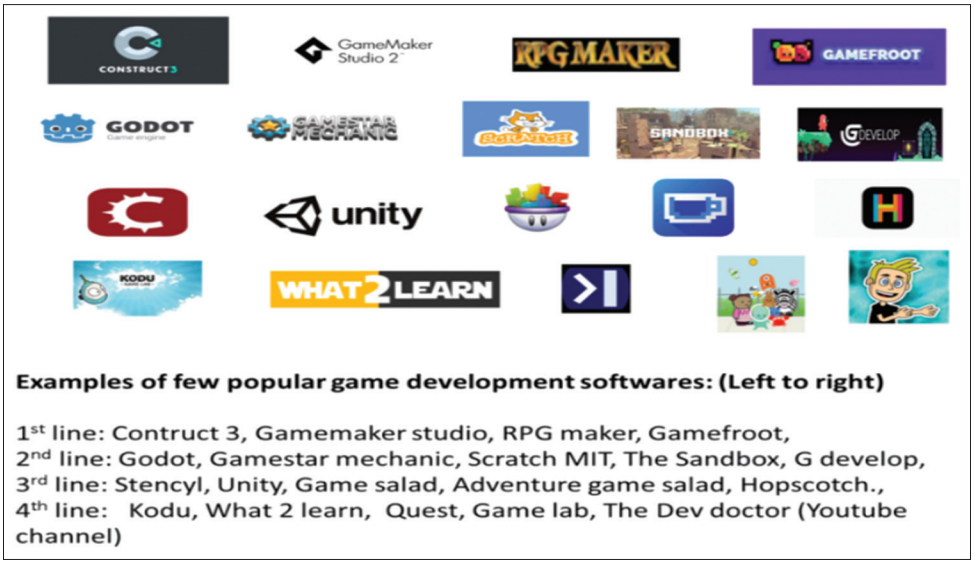
related to cardiovascular and neuromuscular Physiology with the practical solutions and achievable suggestions. Inclusion criteria: list of articles from PubMed, Medline, and Cochrane by means of manual search with the keywords include Gamification on Physiology teaching, learning; serious games created/developed for medical Physiology. Exclusion criteria include the articles that does not involve medical Physiology teaching, involve gaming app application, card board games, and quiz games.

Software and apps to design, to create, and to develop an active and serious game in Physiology: Serious games are the games developed for a purpose other than entertainment, such as teaching a specific knowledge or skill.[19,20] Serious games have been shown to increase learner satisfaction and knowledge gains that can be utilized to improve the transfer of medical concepts via serious active solo gaming over traditional teaching methodologies.

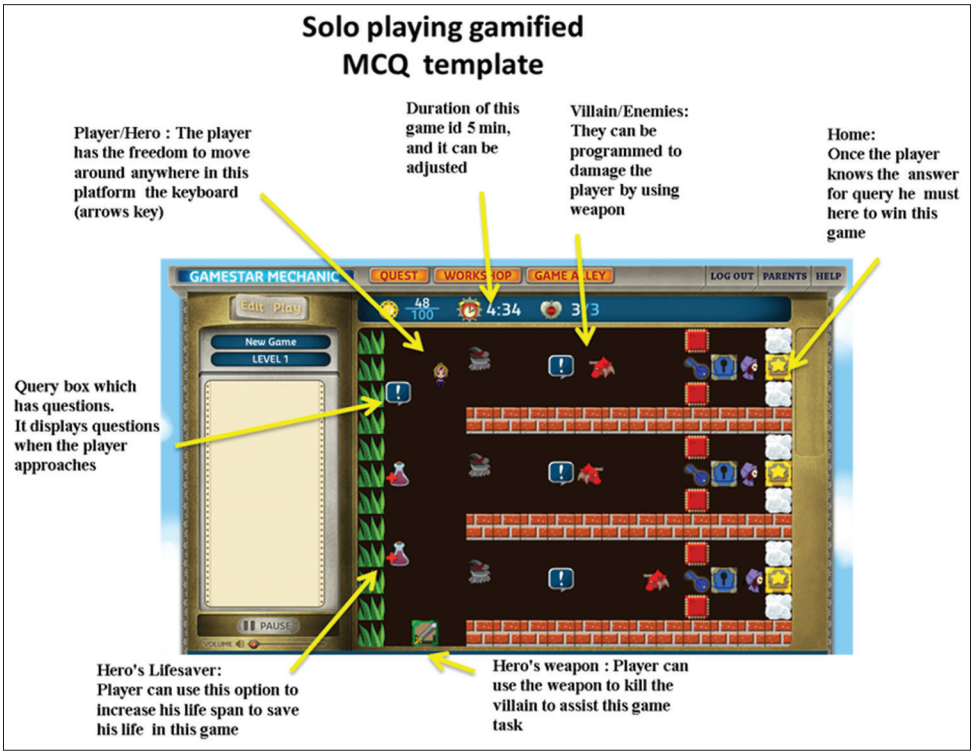
Examples of few popular game development software [Picture 1]: There are various free and paid available software that can be utilized to develop the game according to develop lesson/lecture plan based on our objectives. Some software may require the knowledge of codes, scripts, computer languages (C++, Python, HTML5, CSS3, SQL, and JavaScript). In contrast to this, the drop and drag option software are more user friendly to a medical educator who has limited or no background in computer languages and programming. Moreover, any interface that is used by a medical educator requires a lot of time to practice and familiarize him/herself with the tools to create the game based on the academic curriculum and subject-specific objectives.

Designing a serious game

Being a medical educator from Generation Y, who teaches the Generation Z (predominant MBBS students at medical schools now), one of the major factors we face is curriculum transformation that involves technologies. We do often brainstorm with the colleagues about the various new unique methods of teaching that can be used to engage the students' learning and understanding the important concepts of Physiology without the element of boredom. We commonly use the blended teaching mostly which involves didactic lecture, flip classroom, online quiz, small group discussions, demonstrations, observation, assistance, performance, Jigsaw method,

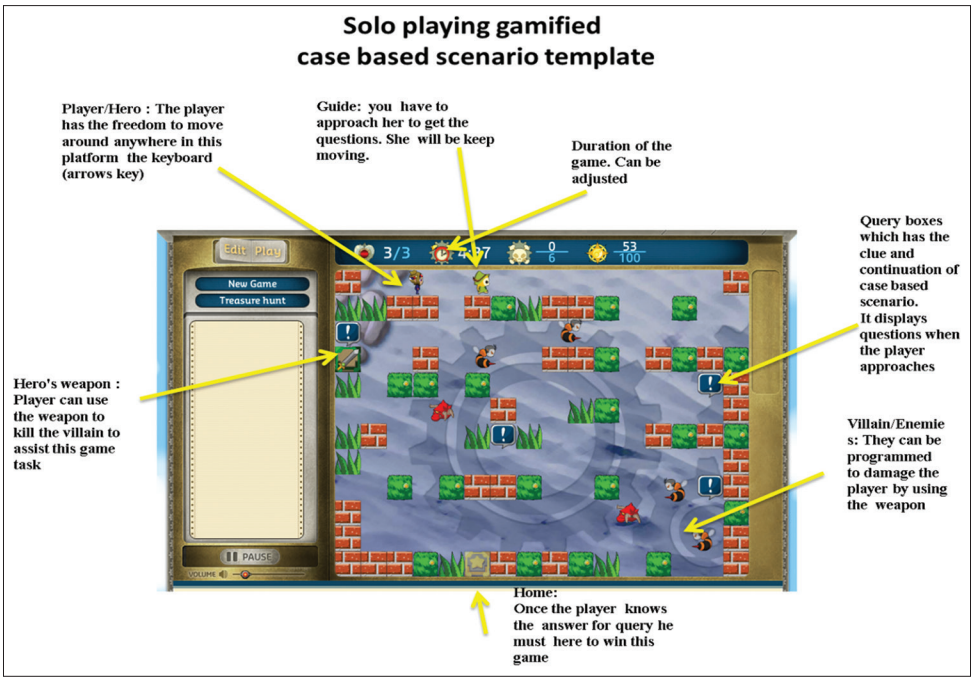


Picture 1: Few popular development software can be used for the game development



Picture 2: Screenshots of Game 1 for the purpose of assessing, teaching and learning the Physiology for 1st MBBS students

Peytons 4 step approach, seminars, quiz competition, and puzzles. To involve the gamification in Physiology teaching, learning, and assessment, we explore the options to design and develop a solo playing game where it provides the platform for the students to enjoy the game as well as favor learning the subject. Various gaming platforms and software engines were found to be freely available to create an education game. However, we found that most of the platforms were difficult to use as they require an intense background of computer languages and coding to create a game. Our intention was to create a basic game or to utilize the gaming elements by incorporating the concepts of Physiology and to give the learner an experience of playing and having fun. Finally after the long search we zeroed down to Gamestar mechanic™.created by E- Line media With two months of practice and learning, we were able to develop a gamified template that can be used for assessing the knowledge of Physiology among first year MBBS students.



Picture 3: Screenshots of Game 2 for the purpose of assessing, teaching and learning the Physiology for 1st MBBS students

Explanation of game development

Gamestar Mechanic is an online free service offered by E-Line Media that helps the users to learn how to design video games. The template can also be shared online for other users to play and experience. We have used this interface after sign up/sign in, and it will lead to their website (https://gamestarmechanic.com/log/in). Click the workshop and build a new game button. By using the mouse, you can select the avatar (hero), enemy (villains), and blocks to build the template-like walls. The position of the characters can be set according to our need. The questions specific to your field of interest can be inserted using a tool box called as sprites that sometimes can be claimed/earned only after finishing few rounds of playing the default game in Gamestar mechanic app. The more you spend time the more you will be familiar with. The good things with this app is that it does not need any coding knowledge to design a game. There are many free YouTube videos to assist the new developer in this case. Since this platform connects with a community over 250,000 designers whose games have been players over five million times, we can get assistance about our clarification and also allow us to publish our designed games to the public with free of cost.

The first serious game Game 1: Cardiovascular Physiology (linked below) that we created has a duration of 3-5 minutes and involves characters such as hero, villains at various level, and their personal characteristics can be altered at any time in this game. The scenario of the game is explained with the help of various comments and queries wherever required. The player (hero/avatar) has to complete the game by destroying all the villains or threats using the various assigned direction keys to move up, down, side, and fire using the keyboard. The same software was further explored to develop a second serious game Game 2: neuromuscular Physiology (link given below). The hero/avatar will be eliminated if he gets attacked by villains in the game. His role is to protect himself and have to collect all the queries/comment boxes which contains core concept of Physiology knowledge and scenario. Both these games can be played by a student using a keyboard on a computer where the student will get the experience and fun associated with playing games with the simultaneous experience of gaining knowledge of core concepts of physiology.

Difficulties faced by a medical professional during the process of gamification

- Lack of adequate knowledge of computer language programming, coding, and software development.
- Paucity of time due to other academic commitments.
- Requires high level of understanding of the interface software engine that we are working with.
- Persistence and repeated practice by the educator needed.
- Needs prolonged concentration and sitting posture of the educator which leads to eye strain, headache, and back ache.
- Some platforms which have drag and drop features were easy to manipulate compared to other platforms that require programming and may not have inbuilt options like insert comment/edit/delete.
- We required the additional support from software and game developers sometimes to clarify the technical doubts.

- While designing a game, it was difficult to convey all the knowledge, concepts of Physiology, or any subject in the form of serious game.
- A significant duration of time will be required for preparing the structured script and language prior to the game creation of particular body system.
- The lag in the process of game creation as the computer specifications were not upto the mark required for such software platforms.
- Consumes time and work even after office hours as we did not have time during the routine day as it was occupied by our academic schedule.

Link for game 1 and game 2

The link for a recorded video of playing the solo game for multiple choice questions and case-based scenario for Physiology by using the Gamestar mechanic software were provided below:

https://www.loom.com/share/82d97920b4514286967b91654bb976d5?sid=6e59357e-f998-433e-be88-e83d7c2df02e [Video]

Screenshots of Game 1 and Game 2 for the purpose of assessing, teaching and learning the Physiology for 1st MBBS students has been attached for the reference [Pictures 2 and 3],

Description of game 1:

Solo playing game for multiple choice question (MCQ): In this game, a sample of MCQ question from cardiovascular physiology was given.

Question: Which artery carries deoxygenated blood?

Answer: The answer is available in one of the lanes of 1, 2, or 3.

Instructions

Lane 1: Aorta. If this is the answer then move forward and open the key

Lane 2: Systemic vein. If this is the answer then move forward and open the key

Lane 3: Pulmonary artery. If this is the answer then move forward and open the key

The student can play the game by using keyboard arrow keys (move around) and spacebar (weapon). The student enjoys the game and simultaneously enjoys the knowledge of circulatory Physiology.

Description of game 2

Solo playing game for case-based scenario: In this game, a case-based scenario from neuromuscular Physiology was given which was separated as four parts and given in queries (numbered 1, 2, 3, and 4).

Query1: Gameysio is a 23-year-old warrior. So far he is strong and fought many wars. However, over the last couple of months, he is experiencing symptoms like weakness, rapidly exhausted, could not continue to fight no longer than 15 min. He became tired and fatigue soon. Find the query number 2 to know more.

Query 2: He was evaluated by her physician, who suspects muscle disease and ordered for blood tests. Go to the query 3 to know more and help him sooner.

Query 3: While awaiting the results, the physician initiated a trial of Pyridostigmine, an acetylcholinesterase inhibitor. Gameysio immediately felt better while taking the drug; his strength returned to almost normal and finds stronger. Meanwhile, the results of the antibody test were positive. Find the disease and help him with the possible medications. He is on war already. Go to query 4, you are almost there to find his problem.

Query 4: Based on his symptoms and test, he was diagnosed with Myasthenia gravis. Kindly explain his role of drugs at neuromuscular junctions (NMJs). You can reach this diagnosis after you finish this task.

In order to reach the other queries, the player has to fight (space bar) the villains and move around (arrow keys). The game can be completed only if all the villains are killed and the student reaches the goal at the end.

The students can make multiple attempts to complete this task with varied time durations. The student enjoys the game and simultaneously enjoys the knowledge of neuromuscular Physiology.

Advantages of serious games

- Significant improvement in delivering academic content to the students and to escalate their performance using gamification over traditional methods.[21]
- Gamification promotes the critical thinking and problem-solving skills, communication, creativity, collaboration.[22]
- Video games with structured duration of exposure and regulated characteristics and design can have significant influence on individual behavior and performance.[23,24]
- Could be an alternative way in the Generation Z (more prone to psychological stress than earlier generations[25] to reduce the depression, stress, suicidal thoughts, and psychiatric conditions management).[24,26]
- Gamification also may favor the self-paced learning, a major principle of adult learning theory principles that were to enhance through learner controlled and

real-time feedback whenever it is convenient to them with the scope of repetition.[27]
- Gamification can be used to enhance the students motivation, engagement, effectiveness, and efficiency.[28]
- Improves and evolves the human-computer interaction and may lead to the increase in human machine interaction and understanding efficiently.
- Gamification concept provides instant rewards and motivation through achieving badges, medals, cups, and points with review and feedback.
- Provides the opportunity to play, learn, and simultaneously interact with their colleagues in a single platform with continuous feedbacks via online gamified flipped class rooms.[29]
- Can be applied and adopted by all generations as one of the ways of teaching learning methodology in blending teaching.
- With the relevant background, the medical educator has a high advantage to incorporate the concept of medical Physiology when developing the game characters and its design like subject specific and precise compared to game developers.
- May be incorporated as one of the OSPE station in the medical student summative and formative assessment using the solo playing gamified MCQ or case-based scenario.
- Assessment reports, point and individuals scoring and performance analysis using gamified platform is quite convenient and manageable.[30]
- Gamification has the ability to improve the students visual reaction time and reflexes[31] essential to improve the somatosensory connectivity among students which is crucial for doctors.
- The gamification elements and artificial intelligence tools on gamification can be added as an elective via the structured online courses (asynchronous learning) despite the routine medical subjects. Guidance/assistance from the gaming faculty expertise as guest lecture may be planned.

Limitations of serious games

- Development and running costs at the initial stages is high till you create the template.
- Need time-to-time assistance from the game developers which may delay our schedule.
- Game design (contents, graphics, and characters) must be highly focused and primarily limited to education rather than recreation with quality control from the fellow colleagues.
- Lack of interest in computer coding and software will affect the educationist involvement in gamification for education.
- Clinicians and scientists may not find enough time to contribute on the game creation and development.
- The future generations or the same generation of students who may not find it interesting over the time. Hence there is a need to update and evolve with various gamification or similar modalities.
- Need smart classroom with high-speed WiFi facility.
- Gamification or serious games may be considered as a barrier for few students who were not familiar or find distracting about the games in education.[18]
- There is a minimum need of laptop or smartphone with adequate random access memory (RAM) and processor to run the game.
- Gamification cannot be applied at all the time as it may dilute the discipline and ambience of the classroom which is highly needed in medical education. Effect of gamification depends on the various students personality and their characteristics and some students did not really show interest in it.[32]
- The motivational outcomes of gamification may vary for different individuals based on the diverse game design.[33]
- Gamification reported to have different impacts on intrinsic and extrinsic motivated learners and may influence their flexibility, creativity, and well being.[34]

Discussion

Despite the traditional quote: work while you work and play while you play, the concept of gamification which involves both playing and working is evolving in medical education. So far only one original research study has been conducted by applying the serious solo playing gamification on Physiology learning and teaching among medical students for the revision of Physiology along with Anatomy for the biomedical science students.[18] Similar studies using gamified tools or customized and designed apps to enhance the medical students learning on electrocardiogram (ECG) reported to be more effective.[35] Medical students showed marked changes in their motivation, attentiveness, and learning management compared to traditional methods following digital gamification.[36] A similar approach was made to teach the acid-base physiology for the first year medical school students and student's response were remarkably positive.[37] However, it is to be noted that the medical educator qualification is not adequately enough with technical knowledge to incorporate in coding and development of gaming software. The basic curriculum and the qualification of medical subject teacher/instructor do not essentially cover/expose them to learn or attain the expertise for curriculum which includes gamification (gaming platforms and related software development). Therefore, the utmost involvement and extreme passion by the educator is a must to incorporate the gamification concept toward teaching, learning, and assessment.

Conclusion

Most of the time a busy medical educator thinks that new technologies are outside the scope and purview of their profession. Hence, it is the need of the hour to incorporate electives in medical curriculum that involve coding, gaming, and various softwares sensitization programs towards gamification and AI during their undergraduate and postgraduate medical specialization. In addition, the creation of interfaces or apps that involves majorly using drop and drag options is required and to be considered. These will pave the way for medical educators to design various serious solo playing games for medical students' teaching, learning, and assessment. The evolution of gamification, artificial intelligence, and its role in education can be adopted as one of the components of curriculum as electives in medical schools for undergraduate and postgraduate medical students.

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Conflicts of interest

There are no conflicts of interest.

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