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The impact of gamification and potential of kaizen in radiology education

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ABSTRACT

Gamification is an emerging tool in medical education that has been increasingly adopted in the field of radiology. The purpose of this non-systematic review is to explore the use of gamification in medical education with a particular focus on new generations of learners and radiology education. This manuscript begins by examining the effectiveness of gamification in improving learning outcomes in medicine and radiology. Future research recommendations and the potential impact of gamification on new learners are discussed. Finally, this review provides insight into a gaming platform, Kaizen, as a promising approach to enhance education by improving motivation and increasing interest in radiology knowledge.

1. Introduction

Medical education is complex and challenging, especially after the COVID-19 pandemic compelled educators to shift to virtual formats. Traditionally, didactic teaching was the dominant medical education format. Lectures and textbooks were the primary sources used to teach knowledge and skills to become competent healthcare professionals. However, these methods have been criticized for being passive and not engaging. The forced virtual format of the pandemic necessitated alternative methods to capture the interest of learners who increasingly felt isolated and remote. In recent years, gamification has emerged as a promising approach to enhance medical education by incorporating game elements into the learning process to improve learners' motivation, engagement and knowledge retention.

Gamification is the application of game elements or game design in a nongame context.[1–4] In education, gamification has utilized gaming elements for various learning activities.[1–3] Gamification has been shown to improve motivation, participation, increase performance and increase short-term and long-term knowledge retention.[5–7] Some of the goals of gamification include improving engagement, increasing course satisfaction and overall making learning more enjoyable.[7,8] This manuscript aims to review the advantages of gamification in radiology education and explore the potential of Kaizen game platform as an effective tool to enhance learning outcomes.

2. Methodology

Librarian services at this institution were used to perform a non-systematic review of literature involving gamification in radiology. The search strategy included two searches on the Embase database. The first search, called the "Kaizen search," was designed to find articles about the use of kaizen in the context of games, education, or learning while excluding quality improvement research. To accomplish this, the search string used the "NEAR" operator to search for "kaizen" within 50 words of terms like "game," "gamification," "gaming," "play," "education," "teach," and "learn." The term "radiology" was also queried and included for specific references. The search was limited to English-language articles and excluded conference abstracts, papers, and reviews.

The second search was a broader search for articles related to gamification in medical education (GME). The search string used the "exp" operator to search for articles related to "gamification" and "medical education" as well as terms like "game," "games," "gaming," "GME," "education," "teach," "resident," and "fellow." The search was limited to English-language articles. The terms and search strategies utilized specific operators to retrieve relevant articles while excluding unwanted ones.

2.1. Terminology

Gamification literature often references similar terms such as *serious*

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game and *game-based learning* or *gamified-learning platforms*. Without defining these terms, deciphering the differences in terminology can lead to confusion for those unfamiliar with the field.

In general, gamification is the incorporation of gaming elements in learning processes to increase learner engagement, enjoyment and participation.[9] *Serious games* are defined as video games designed to aid in the learning process. They can be used in a variety of industries and settings to teach, train, educate and modify behavior.[9–11] *Gamified-learning platforms*, on the other hand, use gaming elements to achieve a specific goal.[11] For example, if the goal is to educate students, the gaming platform will use gaming elements to achieve the specified education goals. While these two definitions have similar implications, serious games can be considered gaming platforms only if gamified elements are present.[11] Game-based learning implies that an existing game has been modified in order to aid in learning or teaching of a skill.[9] Although these are distinct terms, they share the same goal; to enhance learning by making the learning process engaging and more enjoyable.[9] Gamification along with these related terms has been used in various fields of healthcare education to engage learners, increase motivation, and apply previously learned knowledge.[5,12]

3. Previous gamification in radiology

The available literature concerning gamification in radiology education includes the following examples listed below. Studies regarding serious games were excluded.

Second Life, a 3D virtual world game, was used to complement radiology learning in medical student participants. The game was determined to be an effective tool to teach core anatomy and radiology signs to the students, and voluntary participants had better results on the post-test than non-participants (59.0 ± 13.5 versus 45.3 ± 11.5; $P < 0.001$).[13] Second Life was also used to determine the effectiveness of mandatory games in an educational setting.[14] It was concluded that the use of optional gaming platforms is preferred to mandatory participation due to lower scores in the mandatory game, and lower opinions of the game by the learners. Specifically, the mean test score in the year of the voluntary game participation was 74.7% (±19.5%) compared to the lower mean scores in the 2 years of mandatory participation, 71.2% (±21.5%) in 2016 and 67.5% (±21.5%) in 2017 ($P < 0.01$).[14]

SonoGames, a game-based event to teach emergency medicine residents point-of-care ultrasound, was used to evaluate the effectiveness of combining simulation-based training and gamification in radiology training.[15,16] Liteplo et al. found that participants reported that their ultrasound knowledge increased (81%), their enthusiasm for ultrasound increased (87%) and their clinical use of ultrasound increased (61%). A team of radiologists developed a modified SonoGames (SG) that involved three interactive lectures and three competitive rounds for use in radiology residents.[16] Participants' self-efficacy scores were calculated for multiple knowledge and hands-on skill related variables, which all demonstrated increase after the SonoGames. For example, the general knowledge variable self-efficacy score in male residents demonstrated an increase of 20.13 points and an increase of 10.88 was seen in female residents (who had higher baseline pre and post scores) with a *p*-value of 0.018.[16]

The RADGames, a radiology competition, was designed by medical students to increase interest in radiology and improve image reading abilities.[17] The games were held via Zoom using breakout rooms and quizzes to facilitate the competition.[17] At the conclusion of the event, 77% of those who responded to the post-event survey perceived an increase in their confidence in basic imaging interpretation and 81% reported an interest in radiology.[17]

RapRad, an e-learning platform, was used as a learning tool for medical students, first-year radiology residents, and radiology technicians. The gamified platform was designed to teach the participants to detect pneumothoraxes on chest - X-rays. RapRad was found to improve the participants' diagnostic confidence and reduce errors while offering an engaging learning experience.[18] Of the participants who completed the game as well as the surveys, there was increased diagnostic confidence in pneumothorax detection from a pre-event mean (±SD) score of 4.3 ± 2.1 to a post-event final mean score of 7.3 ± 2.1 ($p < 0.01$) with 10 representing the highest possible score. Additionally, 93% of the participants who completed the survey indicated that they would use the game for learning purposes again, and 87% indicated enjoying the process.[18]

Table 1
Simplified summary table of gamification literature.

Name	Objective and target audience	Qualitative outcome
Second Life	3D virtual world game to teach core anatomy and radiology signs to medical students	Voluntary participation resulted in higher post-test scores and was preferred over mandatory participation in learning games.
SonoGames	Game based event for emergency medicine residents to learn point of care ultrasound. Later adapted for radiology residents	Participants reported increased knowledge, interest and use of ultrasound as well as increased self-efficacy scores for multiple knowledge and hands-on skills related variables.
RADGames	Competition via zoom for medical students to improve image reading abilities	Perception of increase in image interpretation and interest in radiology
RapRad	*E*-learning gamification platform to teach medical students, 1st year radiology residents and radiology technologists to detect pneumothoraxes on chest radiograph	Improved participants' diagnostic confidence and reported enjoyment
Kahoot[b]	Web based gamification platform, adapted by individuals to use for education of radiology residents	Positively impact learners' attitudes and increase their interest; Improved satisfaction survey and desire for future utilization
ARS[a]	Audience response system used during lectures given to radiology residents	Positive impact on information retention both short and long term

[a] ARS represents a platform where content is created by individual educators and subsequently adapted using the platform. This is in contradistinction to the remaining platforms where the software developers create the content directly into the platform.
[b] Kahoot represents a platform where both individual and developer-created content is available.

The aforementioned gamification platforms represent those platforms where the software developers created the content, which usually results in a narrower focus of subject material e.g. ultrasound of emergent clinical issues or medical school level anatomy. Therefore, the previously discussed platforms are in a different category from those discussed below. Kahoot and ARS both represent platforms where content is created by individual educators and then subsequently adapted using the platform.

Kahoot is a web-based gamification platform that has been used to teach radiology residents.[4] Multiple features in Kahoot can be used in radiology education, such as the quiz setting, jumble setting, leaderboard/rewards, blind Kahoot and the challenge feature. The jumble setting allowed for the organization of images in chronological order and could be useful for learning the sequences of disease processes. The use of Kahoot appeared to positively impact learners' attitudes and increase their interest.[4] Although data is lacking regarding the success of Kahoot in radiology specifically, the impact of Kahoot on motivation of Ophthalmology MBBS students showed that intrinsic motivation was significantly improved ($p < 0.05$) when using Kahoot with online lectures compared to online lectures without Kahoot.[19] Furthermore, radiology technology students using Kahoot had statistically significant higher satisfaction survey scores (93%) and 93% of students felt that Kahoot should be used in the future.[20]

Gamification via audience response system (ARS) and teaching

simulations are additional methods that have been used to enhance the learning process.[21] The use of ARS during lectures had a positive impact on information retention in radiology and gynecology residents.[22] When comparing traditional didactic sessions vs ARS, Awan et al. found that the use of ARS resulted in six times increased likelihood of learners studying radiology outside of work. Additionally, there may be benefits to using task simulations and/or communication simulations in radiology resident education.[21] A randomized study of radiology residents by Rubio et al. found that not only did residents show higher learning with ARS immediately after lecture delivery ($p = 0.02$) but a 3-month follow-up showed greater retention of knowledge ($p < 0.001$).[23] In addition, favorable response has been shown for ARS by both residents and attendings with anonymous survey data using a 1–5 Likert-type scale demonstrating that residents learned better with and were more likely to attend lectures using ARS (4.03; 95% confidence interval (CI), 3.74–4.32 and 4.53; 95% CI, 4.25–4.81, respectively). Attendings also felt residents were more engaged (4.33; CI, 3.87–4.79), and that using ARS helped them gauge resident understanding (3.67; 95% CI, 2.95–4.40) and prepare lectures (3.33; 95% CI, 2.68–3.98).[24]

An important limitation of gamification platforms is that they are ultimately dependent on the quality of the underlying content and quality of questions. Good quality questions are inherently difficult to create and very time-consuming to write. A possible solution to overcome this barrier would incorporate pooling of interinstitutional resources and good quality question banks to enhance the final educational product. A simplified overview of each gamification name, objective and outcome is provided in Table 1, noting the limitation of comprehensively comparing the different gamification platforms. Accurately comparing the effectiveness of each platform is outside of the scope of this review given the difference in objective measures utilized in various studies.

In addition, not all interactive educational gaming platforms have outperformed traditional didactics. In the direct comparison of an interactive digital game (Tic-tac-toe via Microsoft Powerpoint 2007 played in teams) and traditional didactic lecture with pediatric gastrointestinal radiology, fourth-year medical students given traditional didactic lectures made higher scores on a final test, reported a greater understanding of the material ($p < 0.001$) and greater recall ($p = 0.004$) in comparison to those who received the interactive digital game. The students in the lecture group scored 4/5 versus 3.6/5 in the game group with $p = 0.045$.[25] It was determined that digital games did not effectively replace traditional learning methods.[25] Therefore, integration of educational content within an interactive gaming platform may provide a more comprehensive experience.

4. Current and future learners in radiology education

4.1. Generation Z and millennials

Graduate medical education is undergoing a shift due to the limited resident work hours mandated by the Accreditation Council for Graduate Medical Education (ACGME) and the emergence of new generations – those born between 1982 and 1996 termed 'Millennials'[5,6] and those born after 1997 termed 'Generation Z' (Gen Z).[26] With Millennials being the first generation to have grown up with computers and e-learning as an integral part of their education, they have shown a preference for collaborative learning and teamwork.[27] Similarly, Gen Z has also had unprecedented exposure to the internet since childhood and has grown up in an era of digital learning.[5,28] As a result, graduate medical school programs benefit from adapting their teaching approach to meet the changing needs and expectations of this new generation.

Gen Z learners prefer independent, self-paced learning.[27] They desire, and in some cases expect, convenience, immediate access to information, access to honest feedback and immediate response to questions.[27,29] Gen Z learners prefer visual learning environments including information presented using videos, stories, simulations, online quizzes, case studies, etc.[27] Though individuals in Gen Z can expertly use the internet, their ability to assess the validity of information may be limited.[28,30]

To that end, an interactive and competitive app-based game such as Kaizen could fulfill many of the desired specifications of current generation learners to optimally engage and educate. For example, Kaizen provides instant feedback via leaderboards and has instantaneously available explanations to its questions.[12,29,30] Additionally, the explanations on Kaizen can involve written responses, videos, and/or links to articles or educational sites, thus providing a variety of reliable sources for learners to reference.

4.2. Motivation for multiple choice gamification via cell phones and competition

While radiology residents will prepare for the oral board-type certification exam as of April 2023, the Core exam will remain the Qualifying test for radiology residents, which continues to be a multiple-choice exam. Both multiple choice and oral testing can be improved by gamification. Gamification provides an additional avenue, outside of traditional learning, for students to test and gain knowledge, while also interacting with peers. It has been shown to improve student engagement.[2,12,31] Gamified-learning platforms such as websites, cell phone applications, and virtual patient simulations are proven to engage learners, enhance enjoyment and aid in clinical-reasoning practice.[32,33] Similar to competitive sports, gamification utilizes friendly competition to motivate learners to engage with peers while simultaneously improving their knowledge.[11,34] The remainder of this paper will focus on the educational gaming application, Kaizen, and the impact on such platforms for future generations of learners.

5. Kaizen gaming platform

Kaizen Education is an app-based software platform developed in 2012 at the University of Alabama at Birmingham (UAB). This platform was named based on the Japanese term meaning 'continuous improvement.' The app allows administrators to create games and input questions at a set time or on a continuous basis. The questions can link to online content, including websites, podcasts or YouTube videos. The app engages learners through multiple choice questions, peer competition and the incorporation of multiple gaming elements.[1] Along with multiple-choice questions, the game designer and/or educator can provide an explanation that is immediately available once the learner has answered that specific question.[1] Learners can compete individually or as a team and are able to access a leaderboard that shows individual rankings and team rankings.[12] The game designer can choose to award badges to positively reinforce engagement with the gaming platform.[2] Common elements used in Kaizen Education are leader boards, point based level badges, hot streak badges that award multiple correct answers in a row and participation badges for consistently answering questions for a certain number of days.[1] Kaizen Education uses common elements found in educational games such as clear objectives, rules, rewards, player interaction, feedback and the ability to compete with peers and/or with oneself.[34]

Regarding the use of Kaizen in Millennials, 133 first-semester undergraduate nursing students (all Millennials) used Kaizen throughout a semester. Focus groups were then created to analyze feedback from using Kaizen. These focus groups assessed several topics, including the perception of team competition, motivation factors, course material engagement and overall reflections. After the focus groups, a software program for data analytics coded the data and assessed for emerging patterns. The researchers found that the Kaizen Education game improved the nursing students' knowledge retention.[12] The majority found their teams to be motivating and allowed them to further connect with their peers.[12] Additionally, participants enjoyed viewing the leaderboard and comparing their current and past standings on the

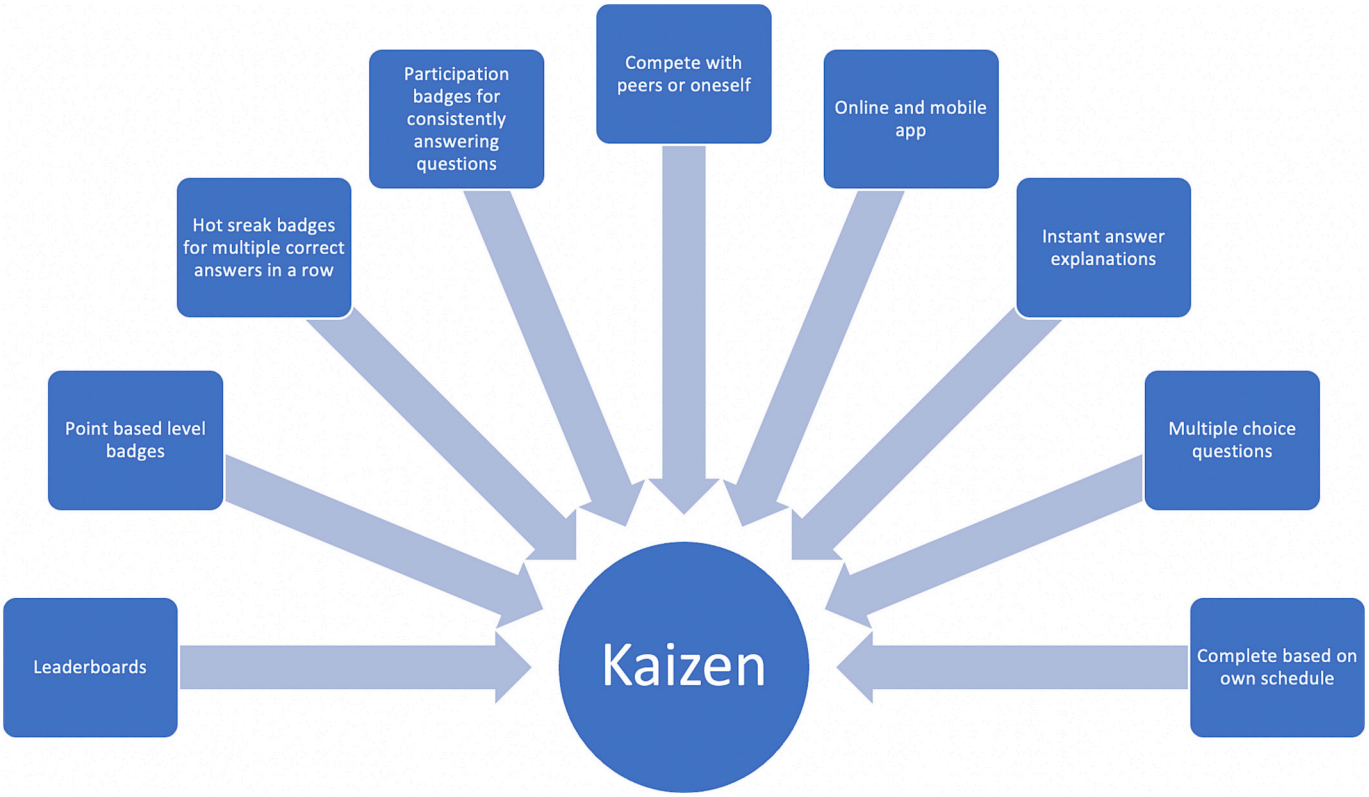

Fig. 1. Kaizen attributes.

leaderboard.[12] Kaizen was felt to be a helpful learning tool because it was risk-free. The students were able to learn without a grade penalty for answering incorrectly.[12]

Kaizen has been utilized in other settings with different types of learners. Kaizen education has been used to teach principles of Rigor, Reproducibility, and Transparency to learners. Willig et al. assessed 126 researchers in nine institutions, found that the use of Kaizen correlated with high pass rates (80% passing on first attempt and 20% on second attempt) on exams. The study concluded that gamification was effective at engaging learners and teaching them the intended content.[35] Similarly, the Kaizen game was assessed in Master of Public Health (MPH) students. A quantitative descriptive study was performed involving 27 Kaizen games. A total of 21 met a pre-determined set of criteria and were analyzed, involving 595 learners from 41 institutions. From January 2017 to October 2019, question accuracy ranged from 38% to 99%, with a median of 87%. Games performed from January 2020 to November 2020 showed a median accuracy increase to 91%. In a separate game to assess competency, 242 students across multiple MPH tracks had an average correct response rate of 65% with varying competencies achieved depending on certain thresholds (50% or 70%).[1]

The Kaizen Education gaming platform has also been used as an alternative method to satisfy the good clinical practice (GCP) mandated training, which is required by the National Institute of Health for all clinical research investigators. Kaizen was found to effectively teach content and over 60% of participants reported that the game improved their knowledge.[36] Additionally, Kaizen has also been used for diabetes education; adult diabetes patients participated in a Kaizen quiz after their standard scheduled visit with their physician.[37] Participants were enthusiastic about learning through a gaming application and felt empowered to discuss their health with healthcare providers.[37] Further studies using the Kaizen gaming platform in diagnostic radiology resident education are necessary to evaluate its effectiveness and practicality in enhancing the aforementioned metrics. A summary of the attributes of the Kaizen gaming platform is provided in Fig. 1.

6. Conclusion

Gamification can create an engaging avenue through which learners can apply knowledge. As Millennial and Generation Z individuals represent the majority of Graduate Medical Education learners, gamification is a suitable education method which often targets their expectations. A method such as the Kaizen app for gamification can offer convenient elements of education and have significant appeal to younger generations.

Declaration of competing interest

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