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# Gaming: Joy in radiology education

**Radiology residency programs** find the fun in learning by leveraging cutting edge technologies. A new comprehensive review on **radiology education using gaming** technology, presents valuable insight into the value of **gaming**, game types and gaming principles, **artificial intelligence** applications and continued education.  The study published in [Academic Radiology]() examines the pros and cons of gaming as radiology education tool and potential obstacles in successful adoption of gaming in radiology residency programs.

Radiology education, especially in **diagnostic radiology residency programs**, has transformed in recent years as innovation creates new tools and applications. Transitioning from the oral board examination to the written **CORE** exam a compilation of multiple-choice questions, education that wants to engage trainees with **interactive content** in lectures is becoming more and more appealing. Interactive lectures currently used in radiology residency programs include lectures with flipped classroom techniques and the use of technologies that incorporate gaming concepts such as audience response systems (**ARS**), including popular pop culture games like **Jeopardy** and **Pictionary**.

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The study states a game is defined as an “interactive computer application, with or without a significant hardware component, that has a challenging goal, is fun to play and engaging, incorporates some scoring mechanism, and supplies the user with skills, knowledge or attitudes useful in reality." Educational gaming is goal-oriented; specific objectives to master educational content are implicit. This is in direct contradiction to conventional video games that are played purely for entertainment.

**Games used in medical education are inherently interactive**, probing players to reach complex decisions. A game will present players/trainees pertinent knowledge or skills necessary for their success. In terms of **diagnostic radiology**, the acquired skills translate to success in **interpreting radiology exams**. Finally, gaming incorporates a scoring mechanism, which allows for competition among players, further fostering engagement and interaction (8, 9, 10).

The research sheds light on the popularity of gaming in radiology education, its importance, and the principles behind it. The various types of games used in radiology education, their development, and game validation are explained. Applications of gaming such as artificial intelligence (**AI**) and continued medical education (**CME**). Finally, the scant data of learning outcomes with regards to gaming, barriers for the adoption of gaming in radiology departments, and advantages and disadvantages to gaming are presented.

**Principles of Gaming**

Games, and the concept of gamification, have been the subject of a large body of research related to human **behavioural psychological** principles. There are multiple different principles and frameworks that attempt to explain the underpinnings of game interactions. Certain authors have established as many as 36 individual game design principles. These frameworks share a common theme, the notion that **gaming encourages an intrinsic motivation for success**. Playing games is not compulsory, but optional for players. This intrinsic motivation encourages millions of gamers to voluntarily spend time and money studying and learning new techniques to help them succeed in various disciplines. Leveraging this type of investment for educational purposes has immense potential.

The study references Ki Karou of the MIND Research Institute in Irvine, California, a nonprofit organisation dedicated to improving math education, described **five gaming principles** that summarise the overlapping themes in many of the described gaming frameworks. The researchers adapted these principles to education and learning:

**1. Interactivity with informative feedback**

Rather than a simple presentation to the learner, games engage learners with content by promoting direct interaction. Active participation is a key component in gaming. Feedback is equally important and must provide the learners with a sense of their current level of mastery, or lack thereof, with helpful suggestions to correct mistakes or misconceptions.

**2. Meaningful goals**

An engaging learning experience establishes clear and concise goals that are not only achievable, but also hold meaning for the learner. Goals, which are a large source of intrinsic motivation for the learner, should be specifically relevant to a learner's practice. For the radiologist, goals should enhance patient care and outcomes.

**3. Experience of growth**

Active engagement is predicated on the feeling that goals are achievable. Incremental success encourages learners and provides them with a sense of achievement and pride as they grow in knowledge and confidence.

**4. Feeling of safety**

Philosopher John Dewey said, “Failure is instructive.” Giving students the opportunity to fail in an environment safe from punishment or belittlement is extremely important. Students may be driven by fear of failure, but failure is not to be feared. The lessons from failure must be embraced as a learning opportunity.

**5. Engaging the senses**

Lastly, providing varied interactions, information presentation techniques, and strategies are helpful to keep the learner engaged.

**Cognitive Load**

The excitement surrounding gaming as a learning tool must be balanced with the amount of cognitive load delivered during the learning encounter. Originating in the 1970s, cognitive load theory describes intrinsic and extraneous loads that must be correctly tuned to promote the ideal learning environment. Intrinsic loads are contingent upon the complexity of information at hand. For example, first-year residents entering their **neuroradiology** rotations may feel overwhelmed by the complexity and nuance of the myriad types of brain tumours that they will be expected to be able to identify. Other examples include assessing ankle fractures via the complex Lauge-Hansen Classification, or explaining the physics behind **MRI** scanning technology and the role of **k-space**. These topics impart a large cognitive load due to the breadth and complexity that is inherent in each.

Extraneous loads concern the complexity of the presentation of information. For example, showing the complete gamut of illustrations and acronyms representing the Lauge-Hansen Classification all on a single slide would be impossible for a novice resident to effectively process and contextualise. In the aforementioned MRI physics example, simply displaying images of k-space for a given MRI image and describing it as a representation of spatial frequency, would be overwhelming and too abstract to a student or resident without first explaining the underlying principles and definitions. These methods of presentation impart a large cognitive load by overwhelming the learner with information or complex concepts without meeting learners where they are in the learning process.

Cognitive load theory not only concerns overly complex tasks or topics, but also tasks that are too easy for the learner, which can be equally detrimental to learning. Educators must avoid overuse of interactivity and challenge that may burden the learner, while also avoiding mundane tasks and interactions for the sake of interactivity. The “sweet spot” between anxiety and boredom was described in 1981 by Vygostky in his seminal book Mind and Society, as the “Zone of Proximal Development,” in which challenge promotes the most engagement. Morsink provided visualisation of this concept. Csikszentmihalyi described an analogous relationship in his 2009 book, Flow: The Psychology of Optimal Experience, asserting that balancing the relationship between challenge and skill leads to an optimal experience, in which the most engagement is likely to occur.

***Figure 1.*** *Morsink's graphical representation of the Zone of Proximal Development described by Vygotsky in his 1981 book Mind in Society. Between boredom represented in green (low challenge with high competence) and anxiety represented in red (high challenge and low competence) exists a zone that balances challenge with competence that promotes improvement and growth. Used with permission from the International Literacy Association. (figure is available online.)*

## Tools Used for Games in Radiology

With the rapid advancement of and access to technology, it is no surprise that the use of technology and gaming in medical education has exploded over the past few decades. Radiology residencies have begun incorporating the use of multiple gaming strategies to supplement the more common didactic or hot-seat conferences which have been the mainstay in postgraduate radiology education for decades. In this section, we review some of the characteristics of several more pervasive gaming strategies in use today, which spans from gamification of existing teaching lectures through ARS and interactive whiteboards, and gamification through simulation whereby the learner adheres to instructional scenarios defined by the teacher.

### ARS

ARS has the benefit of improving residents’ engagement and attentiveness, allowing anonymity, and providing learners with immediate feedback. This in turn allows the educator to recognise gaps in knowledge and tailor the didactic component to reinforce these topics. Rubio et al found that radiology residents had greater immediate comprehension of lecture material and after three months continued to retain that information when the lecture utilised ARS. Similar findings of information retention have been demonstrated among obstetrics and **gynaecology** residents who received information through lectures utilising ARS.

When ARS first became available in the 1970s, it necessitated wired, infrared or **radiofrequency** keypads or clickers, making it largely cost-prohibitive and requiring specialised maintenance, thus limiting its widespread use. With the advent of wireless Internet, several online platforms have developed, lowering cost and improving access for larger audience groups. **Over the past ten to fifteen years, the use of ARS has become commonplace in post-graduate education at the residency level, including within radiology.**

After reviewing feedback from radiology residents following a case review using Nearpod (NearPod, Aventura, FL), Chapman et al found that 90% of residents preferred the interactive use of multiple-choice questions over traditional didactics and 94% preferred an anonymous ARS format over the traditional **“hot-seat”** conference. Although this indicates residents’ preferences, the utilisation of ARS within the radiology education community is still relatively uncommon compared to traditional didactic and case conference formats.

The most often used ARSs in the medical imaging field include Poll Everywhere (Poll Everywhere, San Francisco, CA), Nearpod, and RSNA Diagnosis Live™ (Radiological Society of North America, Oak Brook, IL). Educational experts believe that a potential pitfall of ARS is the perpetuation of the “cueing” effect, in which students may have been unable to answer a question had they not had options placed before them.

### Interactive Whiteboards

In addition to the use of ARS to engage student learners, interactive tools that allow the teacher to illustrate complex or challenging concepts can further solidify key concepts while keeping the learner engaged. For example, the **SMART Board interactive whiteboard** (Calgary, Canada) allows **de novo illustrations** in addition to the ability to **annotate lecture slides** or **images in real time** as discussion evolves during the course of a lecture. Not only does this engage trainees during the lecture, the images and diagrams can be saved and distributed to students, allowing them to return to an earlier concept if needed, something not practical when using a traditional whiteboard. One of the limitations to the use of the interactive whiteboard is the screen size, which precludes use with larger audiences.

Fortunately, several remote meeting tools use screen sharing and whiteboard integration which are not limited to small groups like the in-person use of the small SMART Board. These tools, such as **Webex** (Cisco Webex, Milpitas, CA), allow knowledge sharing across institutions and across continents and can sometimes incorporate different ARS style polling options in addition to annotation and de novo illustration, depending on individual program technology standards (for example, participant interface, capability to anonymise users, etc.). This type of set up has been used by several board review courses, including the Core Physics Review web-based course.

**Teaching Simulations**

Simulation has become an integral part of medical education, particularly in high stakes fields such as military medicine and surgical specialties, allowing residents to perfect techniques without adversely affecting patient outcomes. For example, the use of laparoscopic trainers has allowed surgical residents to perfect skills prior to operating on humans, with many institutions requiring surgical residents master a set of endoscopic or laparoscopic skills on simulated trainers. Although most radiology specialties involve procedural tasks, the use of simulation may be particularly relevant to the field of interventional radiology.

Task simulators have emerged as educational tools to speed the procedure-related learning curve, and have been shown to improve performance in the angiography suite. Past studies investigated the use of simulators in **endovascular** procedures among surgical residents and vascular fellows and found that **repeated exposure to simulation lead to continued improvement in performance in the operating room or angiography suite**, suggesting a program of longitudinal simulation is increasingly beneficial. These types of simulation programs can be readily adapted for the interventionist in terms of angiography simulation by using **smart manikins** or even computer simulation similar to the type employed for **endoscopic training**.

Similar simulations could be used to prepare diagnostic radiology residents for procedures such as lumbar punctures and soft tissue biopsies using phantoms in the simulation lab, allowing repeated attempts to perfect technique prior to performing procedures on rotations or while on call. In one institution, the use of phantom training for ultrasound-guided biopsy not only resulted in improved performance as measured by number of skin punctures and needle adjustments, but also reduced procedure length.

A simulation program that could mimic an “on call” setting would be ideal for the diagnostic radiology resident preparing to take independent call as a second-year radiology resident. One possible format would be one that has a similar interface and functionality as a picture archiving and communication system, allowing learners to actively engage in case review, formulate an impression, and review final interpretation. Another potential use of simulation involves preparing residents for performing ultrasound while on call. In one study, radiology residents reported improved confidence in performing ultrasound after attending simulation sessions and demonstrating improvement on an administered post-test .

Communication simulations have become increasingly popular as a means to improve confidence when dealing with specific topics within the radiology department. This is important because interpersonal and communication skills constitute a core ACGME competency that radiology residents must achieve. Topics include but are not limited to radiation exposure, interacting with ordering physicians, or explaining risk to pregnant patients (40). These simulations include standardised patients as well as trained faculty for assessment and require substantial planning, potentially making them initially cumbersome. The communication skills simulation employed at one institution found that residents had improved confidence following the interactions and felt that the feedback from both faculty and standardised patients was useful (40).

**How are Games Developed and Validated?**

**Game Validation and Psychometric Evaluation**

The ability of games to meet educational goals needs to be established in both the conception and design stage, and also should be a component of ongoing evaluation. Validated education games and **gamified** teaching methods (such as ARS) should cover the material it aims to teach (**content validity**) via an environment that resembles reality (**face validity**), generate **game-metrics** that accurately reflect learners' skill levels (**construct validity**), produce comparable outcome to an established method of teaching (concurrent validity), and accurately predict learners' performance in reality (**predictive validity**). For example, Virtual ED II and its predecessor Virtual ED (Stanford University), online virtual emergency department environments designed for trauma and mass casualty incident team training, were evaluated in a randomised controlled study comparing team leadership performance outcomes versus training with manikins (**concurrent validity**) and with user surveys for usability metrics such as immersion in the virtual world (**face validity**).

Without traditional assessment via direct questioning or testing, scoring mechanisms in simulations rely on analysis of users' real-time performance. To ensure that observable performance measures (game-metrics) reliably reflect users' proficiency (construct validity), psychometric-based design approaches should be incorporated early in game development to define the underlying knowledge, skills, strategies, and decisions required for successful execution of targeted competencies. As an example, Mislev et al applied the strategy of cognitive task analysis to the design of a simulation-based dental hygienist assessment. An expert panel tasked to interview and analyse the actions of dental hygienists in response to carefully designed representative cases successfully identified behaviours that distinguished between experts from novices, thereby guiding simulation task design and scoring.

**Game Design: General Considerations**

Designing an effective educational game, particularly an educational simulation, necessitates collaborative efforts between content experts (radiologists), educators, and software designers to ensure alignment among learning objectives, instructional methods, and the software interface. Unless specialised programming software is available to radiologists without coding experience to directly "program" the simulation, software designers will likely be primarily responsible for developing the simulation and incorporating details such as the platform (web-based or a mobile device app), framework for interactions with the software (directly presenting information versus allowing users to discover it) and gameplay as dictated by the overarching educational goals. When the purpose is instruction, the game should demonstrate how to perform key tasks in addition to providing problems for learners to solve. On the other hand, practice opportunities, feedback, and learner evaluation should be the focus of instruments designed for practice and assessment.

Games captivate users primarily by the interactions through which they can respond to users' choices – a unique attribute that should be leveraged for education. Timely, appropriate and meaningful feedback, which has been shown to be superior in facilitating learning when compared to non-individualised or unsuited interventions, should be given in accordance to learners' performance and needs. Positive feedback reinforces and rewards learning, while negative feedback should allow learners to learn from failures while still enjoying the process. The delivery, time and context of feedback should be optimised to ensure maximum effectiveness. Simulations can dynamically adapt to learners' baseline learning preferences, personalities, in-game performance, and behaviours. Real-time scenario adjustments and/or guidance individually tailor the learning experience, improving overall learning efficacy, targeting specific skills (such as collaborative skills), and making the experience more fun.

Problems applicable to real-life patient care involve task performance rather than regurgitation of learned information. Educational games should help learners gain competencies that are directly transferrable to patient care; therefore, the practice and application of learned skills must be the focus of the curriculum. While one may consider scenarios accurately recreated from real-life situations to be the most effective for learning, higher fidelity may not necessarily lead to better teaching. Features that are irrelevant or too advanced may impede navigability and create frustration, and should be omitted. Design choices must be made with the targeted users' capabilities and levels in mind, and complexity should be introduced progressively so that learners can solidify and develop their skills at an appropriate pace.

**Game Design: Diagnostic Radiology and Procedure-based Simulation**

Face validity dictates that gaming in radiology education results in a product that recreates the activities of a practicing radiologist. The game should allow the participant to not only process the visual information provided by the relevant imaging modality, but also should allow for image manipulation and clinical reasoning. Two-dimensional imaging modalities such as radiographs are relatively easy to incorporate into existing educational game platforms, for example ARS. However, three-dimensional volumetric modalities present more of a challenge in that the user should be able to manipulate and scroll through stacked images to allow for ideal authenticity. Phillips et al have demonstrated the value of scrolling through stacked CT and MRI images in learning while Ravesloot et al have proven that accessing three-dimensional images improves the authenticity of testing. van der Gijp et al also demonstrated that replicating the reading room environment, including the ability to manipulate the display of the images as well as the ambient lighting, further improved testing authenticity.

Game developers, therefore, need to not only consider how to display three-dimensional modality images in a realistic fashion but also must consider the environment in which the images are displayed. Virtual and augmented reality, already prominent in gaming, are making inroads into medical imaging and will likely play a prominent role in radiology education as augmented reality technology catches up to the resolution standards required for diagnostic image interpretation. Validation of developed games can be done in the same manner as prior two dimensional and volumetric imaging educational tools.

Procedural-based simulation adds an additional level of complexity to radiology education gaming. Products exist for simulation of ultrasound and endovascular procedures. High-fidelity simulation of procedural modalities requires the user to receive haptic and performance feedback in addition to allowing for the creation and use of variable three-dimensional interactive anatomy. Many medical education institutions have high-end simulation labs that contain commercially available simulators. To allow for gaming in radiology education, developers could work with the manufacturers of these simulators to create and validate appropriate games.

**Dynamic Difficulty and Artificial Intelligence (AI)**

The traditional model of education has been based on tiered learning objectives that are roughly the same for all learners. That is, all learners at a specific level would be expected to learn from the same learning materials in the same order. For example, all residents may be expected to read a specific journal article during a rotation. While such an approach may be needed for materials such as journal articles, electronic gaming offers the opportunity for more nuanced delivery of information.

There is a concept in gaming referred to as “dynamic difficulty” that refers to games that gradually become more difficult as players progress from lower to higher levels of experience and performance. Dynamic difficulty has been shown to improve participant engagement.

There are methods of electronic learning that deliver information in a tiered approach and are based on dynamic difficulty. While this allows a more individualised means for learning, many conventional dynamic difficulty algorithms have a relatively simplistic approach. Newer deep learning AI algorithms are able to recognise patterns that are beyond the ability of humans to readily perceive. This ability may be useful in gamification, as an AI opponent may be able to identify weaknesses in a human participant that may otherwise go unnoticed, and allow more sophisticated dynamic difficulty adjustments and better educational solutions. For example, an AI algorithm has been developed which was demonstrated to keep pace with players’ abilities 85% of the time. AI-based dynamic difficulty algorithms in gaming may also better optimise a player's satisfaction with the gaming experience.

Historically, most forms of radiology education involve educational resources that are static relative to the learner's ability. Examples of such static media include a textbook or journal article. Gamification has the potential to provide educational materials that may be altered in difficulty based on the knowledge and abilities of the learner. The application of AI to dynamic difficulty in gaming may allow a better tailoring of the educational materials to the learner, and provide an improved educational experience. Consider a radiology resident trying to identify pulmonary nodules on chest radiography, an AI trainer may potentially continuously alter the difficulty of the cases based on resident performance, presenting cases best optimised to enhance resident learning.

**Gaming and Its Effect on Learning Outcomes**

Data regarding the effects of gaming on learning outcomes have been somewhat scant and ambiguous. For example, Schackow et al showed that ARS are associated with improved learning outcomes and short-term retention of learning in family medicine residents, but Robson et al demonstrated that ARS did not lead to increased short-term retention of learning among dental students when compared to similar dental students receiving traditional lectures without audience response. Furthermore, Atlantis et al concluded in a systematic review article that there was an absence of quality evidence on the effectiveness of gaming technologies for improving learning outcomes in healthcare professionals.

The specific effect of gaming on behavioural traits such as motivation to learn, positive reinforcement, and competition are better studied when compared to data regarding quantitative learning outcomes. Sward et al concluded that **paediatric trainees** preferred web-based educational games to computerised flash cards, reinforcing adult principles of **andragogy** (the practice of teaching adult learners), and the importance of learner preference. Students have demonstrated a positive educational response through pre- and post-tests and delineated user control, interaction, and challenge as specific motivating elements of the game, among others.

When specifically applied to diagnostic radiology, gaming provides an opportunity for radiologists and technologists to improve image quality, interpretation skills, and visual perception; and therefore overall performance by increasing attentional capacity, visual field of view, and visual-motor coordination. These skills are especially important to radiologists who are increasingly asked to interpret progressively complex studies while managing interruptions and maintaining focus for long periods of time. Additionally, after 30 hours of video game playing in a 1-month period, individuals without habitual gaming experience demonstrated significantly increased visual spatial resolution compared to their pre-training performance.

There remains a paucity of evidence with regards to the specific effects of gaming on radiology education in particular. No study to date has specifically addressed the effects of gaming on long-term learning outcomes in radiology trainees. Although the behavioural effects of game-based technologies is well documented in the literature, evidence-based studies evaluating the effect of games on radiology trainee learning outcomes are needed to elucidate their effect on radiology education.

**Barriers to Adoption and Strategies for Success**

Gaming and interactive educational experiences represent a novel trend with aspirations of educating future generations more efficiently while fostering critical thinking and reasoning. However, there are barriers that exist, both inherent and external, which preclude forthright implementation. Sanchez-Maria et al described f**our barriers in adopting gamification within education: lack of resources, students' apathy, subject fit, and classroom dynamics**. Expanding on this, a significant barrier is adjusting from the generally accepted method of learning involving a typical lecture-based format.

When evaluating the resources that go into gamification, there are more obvious items such as time commitment (development, implementation time) and cost (initial purchase, maintenance, upgrades), as described above. Additional costs are involved in the infrastructure and classroom dynamic consisting of internet capabilities, new equipment (computers, projector, digital blackboards, etc.), participant response systems, and built in safety features allowing access within the institution's security network. The complexity of medical education gaming is further exemplified by requiring resources for opportunities for continued growth and evolution within the medical field. Examples of this include updated tumour grading systems, nomenclature, structured reporting systems, etc. As medicine changes, there need to be methods and resources for upgrading gaming to reflect the evolving field so as not to become outdated and in order to provide an optimal educational experience. To this extent, medical education gaming has its own unique barrier in that the development process requires expertise not only in technology and education but also in medicine.

The dynamic of the student as well as didactic teacher are also potential barriers. With forward thinking educational programs such as flipped classrooms and group based educational experiences, some students can show resistant attitudes. Students' interest and ability to relate to the gaming experience is paramount in the success of the evolution to using hands on gaming applications in education. An additional barrier in maintaining interest from students' perspective is that the educational experience needs to be applicable to their level of knowledge and training. With medical education, the didactic session is typically provided all at once to all the year levels, i.e., a first year radiology resident will be learning with a fourth year radiology resident. In order to maintain interest, there is need for applicability of the educational experience. One of the faults of game-based learning is that the cyclical content tends to address lower level learning goals rather than higher end levels which may lose the interest of the students with more seniority. As stated previously, AI gaming techniques may be a feasible solution to this problem by incorporating dynamic difficulty. An additional technique that may be used to help alleviate this disparity in education level is that of peer instruction. Short conceptual questions interspersed with a didactic gaming session may offer opportunities for upper level trainees to discuss the question or the case with lower level learners. This has been shown to benefit both participants and has also been shown to increase learning gains.

In addition to the students, the teacher needs to have some familiarity with the technology and applications of the gaming method; when this is lacking, resistance and hesitancy towards implementing educational gaming can be expected. Teachers may not adapt to the new methodology, preferring more traditional methods of instruction that are more comfortable for them. The traditional lecture style is well understood and offers less risk. The insufficient data to support the effectiveness of gaming in education could lead many educators to resist adopting gaming in replacement of established curriculum and lecture based methods.

There are advantages and disadvantages to gaming, and these must be analysed prior to deciding whether to implement games in educational curricula. In addition to the aforementioned resource cost, logistical challenges can also hinder successful implementation of educational gaming. Developing a system for correlating scores to evaluations for students has proven to be difficult. Performance in gaming has not consistently correlated with better grades. Providing an experience that is unique enough to minimise variable past gaming experience is challenging. Some learners will have extensive experience playing games similar to the activities within the learning environment while others may have never played. This can lead to an unfair advantage and inconsistent comparative scoring among learners. In addition, some students may not be interested in gaming. Lastly, the logistics of balancing rewarding participation versus mastery of the skill may prove difficult.

Despite the barriers to implementing gaming in medical education, the benefits are very intriguing. In contrast to traditional lecture based teaching methods which are based on transmitting information with expectation of strict memorisation, gaming allows for critical thinking, complex reasoning, and applications of higher levels of learning and analysis which are critical in medicine. With this in mind, strategies for success in adopting gaming for medical education need to be developed. These may include institutional incentives or other encouragements for educators to utilise gaming methods such as administrative time. It is important for educators to feel supported by their institutional leadership, which is a secondary benefit. From a students' perspective, it has been shown that fun and excitement provided by gaming can highly motivate players. Ensuring that the gaming offers these attributes will help facilitate gaming applications. Using short term data collection such as student feedback, objective data such as pre- and post-gaming performance, and evaluating in-service or certification scores before and after initiating implementation of gaming can assist in demonstrating at the institutional level that these gaming efforts are beneficial.

As many commercially available gaming options are not available, it remains important to share results developed at the institutional level either through community interfaces (blogs), journal articles, or conferences. Until more development and commercially available options become available, games developed by educators will be the most prevalent and easiest to start implementing. Furthermore, as students are the focus and most often more familiar with technology, obtaining their input in the development may also be beneficial. To expand further on student interaction, allowing more opportunities for students in assisting with development through ACGME residency required quality improvement projects are also potential successful strategies.

**Gaming for CME – Postresidency/Fellowship**

Much time and emphasis has been placed on gamification for learning, often directed toward the early stages of learning, such as resident and fellow education. However gamification may also be useful for CME of radiologists after completion of training.

There may be a misconception that most gamers are of a younger demographic. On the contrary, the average age of gamers (based on software purchases) is 37 years old, and the average age of most frequent game purchasers is 41 years old. Approximately 53% of people between 30–49 years and over 30% of people greater than 50 years of age play video games.

**Another myth centres on the notion that busy professionals do not have time to play games.** While corporate executives are often regarded as busy people, it has been estimated that 61% of them play games during working hours. Finally, the gaming experience is often associated with male gender. This is far from true as studies estimate about 47% of gamers are female.

Radiologists are busy professionals, and are getting busier. Some studies have shown that there have been substantial increases in the number of cross-sectional imaging studies over the past several years, increasing the workload of practicing radiologists. After a busy day, the motivation to pursue CME related activities may be low as radiologists need downtime to rest and recuperate. This may make it challenging to find time for CME on the average workday.

Gamification may be the answer. If CME activities were made more “fun” through the use of gamification, radiologists may find completion of CME activities to be relaxing. CME may transition from a necessity that physicians engage in lieu of relaxation, to an activity with the potential for both learning and recuperation.

Gamification has already become a means of learning in other fields of medicine, such as surgery. Surgeons at the Celebration Hospital in Florida have examined playing video games to prepare for complex surgeries. A recent study performed at this hospital demonstrated that physicians who played video games before simulated surgery made 37% fewer errors, and performed the procedures 27% faster.

**Gaming in radiology education remains an exciting, innovative teaching method that has numerous benefits.** In theory, application of science gaming in radiology can improve patient safety, standardise radiology education and quality, and reduce costs. As more radiology programs introduce gaming into their educational pedagogy, more long-term learning outcomes can be assessed to see if in fact gaming technology enhances learning retention. **With more residency programs seeking to find new ways to revamp their educational curriculum, gaming is providing a unique learning paradigm that offers enormous potential to the learner in terms of shaping educational attitudes, behaviour, and knowledge.**

Sources: Academic Radiology
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