Gamification in otolaryngology: A narrative review

Zack K. Westenhaver BS[1,2] ● | Robert E. Africa BBA[1] ● | René E. Zimmerer BS[1] ● | Brian J. McKinnon MD, MBA., MPH., FACS[2] ●

[1]School of Medicine, UTMB Health, Galveston, Texas, USA

[2]Department of Otolaryngology-Head and Neck Surgery, University of Texas, Medical Branch, Galveston, Texas, USA

Correspondence
Zack K. Westenhaver, UTMB Medical Student Class of 2023, Department of Otolaryngology-Head and Neck Surgery, UTMB Health, 301 University Blvd., Galveston, TX 77555.
Email: zkwesten@utmb.edu

Abstract

Introduction: The medical field has incorporated gamification elements into education platforms over the past decade. The standard definition for gamification that has been adopted by most research studies is the addition of game elements and game mechanics within a platform to enhance user engagement. In this review, seven established, consolidated components, as well as an additional new or novel component, will be evaluated: a point system/leaderboards, question banks or gradable content, social interaction with other participants, leaderboards, progress or levels, immediate feedback, badges/icons or a reward system, and the novel component, a story line.

Methods: Two reviewers searched MEDLINE, Cochrane, PsycINFO, Web of Knowledge, and the Nursing Registry. This review compares the one identified otolaryngology study with current residency education gamification practices within the medical field.

The authors searched "residency AND gamification", "residency AND video games", and "residency AND games". After applying exclusion criteria, the 13 remaining studies included a procedure, questions/scenarios, and at least three gamification elements.

Results: Across the 13 studies, the average number of included gamification elements was higher than the minimum threshold of three (3.84). Ten of the studies incorporated leaderboards, feedback, and social interaction; eight incorporated a question bank; and four incorporated progress bars, rewards, and story lines. The otolaryngology study incorporated four of the gamification components: a point system, instant feedback/solution after a question was answered, player-to-player communication, and a leaderboard.

Conclusion: Review of the current literature found that the medical field has limited research regarding the use of gamification in educational platforms. Despite many simulation studies and attempts at gamification, the medical community has not fully embraced gamification within residency education. In closing, the medical education community should establish a definition of "gamification" and survey residency programs to identify desired gamification elements.

1 | INTRODUCTION

The medical field has incorporated gamification elements into its education platforms over the past decade. Current reviews within residency education have discussed the promising idea of introducing gamification elements into teaching methods.[1] The standard definition for gamification that has been adopted by most research studies is the addition of game elements and game mechanics within a platform to enhance user engagement.[1,2] There are many core elements that can be added to gamify a platform. In this review, seven established, consolidated components, with one additional new and novel component, will be evaluated: a point system/leaderboard, question banks or gradable content, social interaction with other participants, leaderboards, progress or levels, immediate feedback, badges/icons or a reward system, and the novel component, a story line.[3] There is significant overlap between gamification elements, and adding any variation of an element could qualify as another element. The authors wanted to minimize this overlap by combining "leaderboards" and "point systems" as one element. The authors included "story lines" as an additional, novel gamification element. Traditionally, a story line is a main component of video games and may be incorporated into a gamified platform.[3] Without a story line, there may be a decline in the use of a gamified platform,[3,4] as user interest may dwindle over time. Increasing the overall number of gamification techniques within a platform is a strategy developers can use to improve user learning and retention.[5]

There are differences between traditional video games (serious games) and gamified platforms. Serious games are a blend of major video-game platforms, technology, or actual games with a particular industry, whereas gamified platforms combine an existing goal, such as education, with game elements to enhance that goal. Serious games can incorporate gamification elements and qualify as gamified platforms, as described previously.[6–9]

Laparoscopic simulation games and other platforms used for surgery education are primarily serious games.[7,10] Although there is an educational component, question banks are rarely utilized for surgical simulation education. Serious games have been used for both teaching skills and didactic lessons,[11] whereas gamification has been primarily used for didactic lessons. Often serious games did not reach the inclusion criteria established by the authors; therefore, most studies included within the authors' guidelines of gamification do not include simulation studies or other serious games.

Within gamification, the number and category of elements vary greatly between studies, ranging from 1 to 6. For the purposes of this review, studies that have less than three elements were not included. The authors decided three elements would be the minimum, as having a quiz component like a question bank and instant feedback on the question would count. However, this would not provide enough

difference to a non-gamified platform and be potentially uninteresting to the user.[3] By requiring a minimum of three elements, studies with more thorough and complete usage of gamification could be evaluated and reviewed.

Medical specialties have started to test gamification within their own educational programs with promising results.[2,12,13] The purpose of this study is to review the current state of gamification within otolaryngology, compare it with gamification within the broader medical field, and identify a direction for gamified educational platforms moving forward.

2 | METHODS

Two reviewers searched MEDLINE, Cochrane, PsycINFO, Web of Knowledge, and the Nursing Registry databases using the search terms given in Figure 1. The reviewers expected more than one study within otolaryngology would fit the inclusion and exclusion criteria, but only one was identified. This review compares the identified study with current residency education gamification practices within the medical field. The researchers explored a wide range of terms to identify medical gamification including "games," "video games," and "gamification" and then narrowed the searches to strictly residency training. After identifying the literature for residency education gamification, the researchers added otolaryngology to the search terms. Figure 1 demonstrates the search methods. Inclusion criteria were as follows: the study included a detailed procedure, included questions, or scenarios. Exclusion criteria included the study contained less than three gamification elements needed to qualify as a gamified education platform. Thus, studies that incorporated less than three components were not included in this review. Studies that
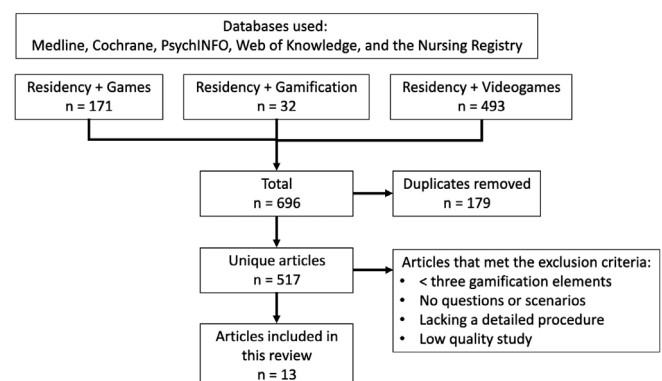
FIGURE 1 PRISMA diagram. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses

TABLE 1 Summary of articles

Gamification journal article	Senior author(s)	Gamification elements	Number of elements	Study design	Medical specialty
Gamification as a tool for resident education in otolaryngology: A pilot study[2]	David Alexander, MD; Michelle Thrasher; Brian Hughley, MD, et al.	Question bank, immediate feedback, leaderboard, progress level shown via badges, and player-to-player communication	4	Used Kaizen software that presented otolaryngology questions that participants could answer and receive feedback for while monitoring progress.	Otolaryngology
Gamification as a tool for enhancing graduate medical education[7]	Christa Nevin, Andrew Westfall, J Martin Rodriguez, et al.	Question bank; immediate feedback; leaderboard; player-to-player communication	4	Developed Kaizen software that presented internal medicine questions that had immediate feedback and answering correctly could earn points. A leaderboard showed individual and team progress.	Internal medicine
Validity evidence for surgical improvement of clinical knowledge Ops: A novel gaming platform to assess surgical decision making[10]	Dana Lin, MD; Julia Park, MD; Cara Liebert, MD, et al.	Leaderboard, story line, and player-to-player communication	3	Surgical decision-making was analyzed by residents using surgical improvement of clinical knowledge ops (SICKO), a gaming platform designed to assess clinical decision making.	Surgery
Winter is here: A case study in updating the neuroradiology didactic curriculum through gamification of thrones solution[11]	Xin Wu, MD; Ryan Peterson, MD; Judith Gadde, DO, et al.	Leaderboard, story line, player-to-player communication, questions, and reward incentive	4	Players were assigned into houses based on Game of Thrones. Conferences were held where participants gained points based on attendance, multiple-choice responses, free response, anatomic drawing, and individual or group problem-solving.	Radiology
The use of gamification to boost residents' engagement in simulation training[13]	B Price Kerfoot, Nicole Kissane	Player-to-player communication, immediate feedback (aggregate score), and rewards incentive	3	Surgical residents practiced using a simulator for 7 weeks. A tournament scored residents, and the top scores received prizes.	Surgery
An online spaced-education game to teach and assess residents: a multi-institutional prospective trial	Kerfoot BP, Baker H	Question bank, leaderboard, progress, immediate feedback, and rewards	6	Urology residents received a pool of questions via email and had to answer each question correctly two times in a row for the question to be removed from the pool. Progress of each question was shown to all the residents, and the solution to the question with references was provided.	Urology

TABLE 1   (Continued)

Gamification journal article	Senior author(s)	Gamification elements	Number of elements	Study design	Medical specialty
Using observation to determine teachable moments within a serious game: A gridlocked as medical education	Brar G; Lambert S; Huang S; Dang R; Chan TM	Feedback, social interaction, and story line	3	Students, nurses, and physicians were recruited to play a game where teaching moments were identified if the pre-planned script was deviated from. There was feedback, a story, and interaction between players.	Emergency medicine
A serious game skills competition increases voluntary usage and proficiency of a virtual reality laparoscopic simulator during first-year surgical residents' simulation curriculum	El-Beheiry M, McCreery G, Schlachta CM	Leaderboard, progress, social interaction, and story line	4	Residents completed five to six segments for surgical simulation training. There were leaderboards for the residents to view, and there was communication between players.	All surgical
The effect of playing video games on fiber-optic intubation skills—Learning to beat the shock clock: A low-fidelity simulation board game for pediatric and emergency medicine residents	Bridges EP, Foster CE, Park DB, Lehman-Huskamp KL, Mark DW, Tuuri RE	Question bank, immediate feedback, and social interaction	3	A knowledge-based test was adapted into scenarios. Residents would go through the scenarios and receive feedback. There was communication between participants and the researchers.	Emergency medicine
Emergency radiology "boot camp": Educating emergency medicine residents using e-learning radiology modules	Minkowitz S, Leeman K, Giambrone AE, Kherani JF, Belfi LM, Bartolotta RJ	Question bank, leaderboard, progress, and immediate feedback	4	Residents completed a pre- and post-survey and played through radiology game modules. There were questions during the interactive session as well as progress and feedback in the modules.	Radiology
Gaming used as an informal instructional technique: Effects on learner knowledge and satisfaction	Webb TP, Simpson D, Denson S, Duthie E Jr.	Question bank, leaderboard, immediate feedback, and social interaction	4	Residents participated in a jeopardy game with a surgical faculty as the game host. They received feedback after each question.	General surgery
Jeopardy!: An innovative approach to teach psychosocial aspects of pediatrics	Jirasevijinda T, Brown LC	Question bank, leaderboard, immediate feedback, and social interaction	4	Family medicine interns participated in a jeopardy game. After each question, faculty lead a short discussion. There was player and team communication.	Family medicine
Preparing residents effectively in emergency skills training with a serious game	Dankbaar ME, Roozeboom MB, Oprins EA, Rutten F, van Merrienboer JJ, van Saase JL, Schuit SC	Leaderboard, progress, and immediate feedback	3	Residents completed scenarios and were scored by faculty on their performance. There was feedback throughout each scenario. Scores were presented in a leaderboard for all the participants to see.	Family medicine

showed percentage correct for each question did not receive credit for the leaderboard gamification element. A leaderboard shows top scores in games, and the authors consider percentage correct tied to immediate feedback. Additional search terms including "residency AND virtual", "residency AND software", and "residency AND simulation" were considered, but these terms were too broad and not within the scope of the study. Finally, gamification within otolaryngology was compared with studies of other specialties which qualified under the inclusion and exclusion criteria.

3 | RESULTS

3.1 | Preferred Reporting Items for Systematic Reviews and Meta-Analyses

After evaluating the search terms "residency AND gamification", "residency AND video games", and "residency AND games", the authors identified 696 articles across the databases. Exclusion criteria were applied, and 13 studies remained with a procedure, questions/scenarios, and at least three gamification elements. The articles are summarized in Table 1, and the gamification elements are outlined in Table 2. Otolaryngology contributed 1 study out of the 13. To better understand how the medical field has attempted to integrate gamification into their educational practices, the authors suggest reading Looyestyn et al. (2017).[1]

3.2 | Table analysis

3.2.1 | Summary of articles

Multiple specialties have attempted gamification including Otolaryngology, Internal Medicine, Surgery, Radiology, Urology, Emergency Medicine, and Family Medicine. This shows an interest across the medical field in incorporating gamification into their didactic curriculum. Across the 13 studies, the average number of gamification elements included was just under four (3.84), which was higher than the minimum threshold of three.

The otolaryngology study incorporated four gamification components: a point system, instant feedback/solution after a question was answered, player-to-player communication, and a leaderboard.[2] This is consistent with the average number of elements across the 13 studies.

In Alexander et al. (2019),[2] the senior author wrote a question bank and incorporated the questions into an online software that gives participants rank and points based on correct answers. Residents who used the software during the year had increased scores

TABLE 2 Summary of gamification elements

Senior author	Question bank	Leaderboard or point system	Progress bar	Feedback	Rewards/ badges	Social interaction	Story line
David Alexander, MD; Michelle Thrasher; Brian Hughley, MD, et al.[2]	Yes	Yes	No	Yes	Yes	Yes	No
Christa Nevin, Andrew Westfall, J Martin Rodriguez, et al.[7]	Yes	Yes	No	Yes	No	Yes	No
Dana Lin, MD; Julia Park, MD; Cara Liebert, MD; et al.[10]	No	Yes	No	No	No	Yes	Yes
Xin Wu, MD; Ryan Peterson, MD; Judith Gadde, DO; et al.[11]	Yes	Yes	No	No	Yes	No	Yes
B Price Kerfoot, Nicole Kissane[13]	No	No	No	Yes	Yes	Yes	No
Kerfoot BP, Baker H	Yes	Yes	Yes	Yes	Yes	Yes	No
Brar G, Lambert S, Huang S, Dang R, Chan TM	NA	NA	NA	Yes	No	Yes	Yes
El-Beheiry M, McCreery G, Schlachta CM	NA	Yes	Yes	No	No	Yes	Yes
Bridges EP, Foster CE, Park DB, Lehman-Huskamp KL, Mark DW, Tuuri RE	Yes	No	No	Yes	No	Yes	No
Minkowitz S, Leeman K, Giambrone AE, Kherani JF, Belfi LM, Bartolotta RJ	Yes	Yes	Yes	Yes	No	No	No
Webb TP, Simpson D, Denson S, Duthie E Jr.	Yes	Yes	No	Yes	No	Yes	No
Jirasevijinda T, Brown LC	Yes	Yes	No	Yes	No	Yes	No
Dankbaar ME, Roozeboom MB, Oprins EA, Rutten F, van Merrienboer JJ, van Saase JL, Schuit SC	NA	Yes	Yes	Yes	No	No	No
	8	10	4	10	4	10	4

compared to residents who did not experience the didactic lesson structure with the gamified platform. A common study tactic was to include a question bank or a pool of questions and provide feedback to the questions. This was supplemented with either player-to-player communication to increase engagement or with a leaderboard showing users how they compared with their peers. Study designs for the 13 studies are summarized in Table 1.

3.2.2 | Summary of gamification elements

Ten of the studies incorporated leaderboards,[2,6,13–19] feedback,[2,6,8,9,13,14,17–20] and social interaction[27–9,13–15,18–20]; eight studies incorporated a question bank[2,9,13,14,16–19]; and four studies incorporated progress bars,[6,7,14,17] rewards,[2,14,16,20] and story lines.[7,8,15,16]

Social interaction in the form of player-to-player communication was heavily valued by the studies. Being able to discuss material with other residents was a major focus of these studies, whether it was in the form of a team-based game or a content sharing of some kind. The ability to compete and participate with other residents is a key feature of gamification that differs from examinations and lectures. Leaderboards and progress bars create competition between users and goals for individuals to achieve and were commonly incorporated as a gamification element; four studies utilized a progress bar. Immediate feedback was also a popular element. The included studies valued the ability to provide teaching and higher level solutions to the users, and only one study included a question bank that did not include question feedback.[16]

A rewards incentive was used in only four of the studies. The rewards were material gifts, unrelated to residency performance. In most of the studies, the residents willingly participated to improve their performance on board exams or improve their knowledge of a niche in their specialty, whereas material rewards seemed to be a lower priority.

4 | DISCUSSION

For an in-depth review of gamification within the medical field, the authors recommend Brigham (2015).[5] The term gamification has become popularized over the past decade. Two main goals of the research team were to evaluate how gamification has been developed and explored by residency programs and to reveal otolaryngology's contribution to gamification literature. Significant progress in research focusing on the use of serious games to teach surgical and laparoscopic skills with the use of popular platforms, new software, and simulators has been made.[21–23] Whereas many promising studies show improvement in surgical skills through laparoscopic simulation and serious games,[10] gamification itself has had less of an impact on residency education. From the 13 studies reviewed, two of the studies were simulation studies that included at least three elements of gamification.[7,20]

There seems to be a distinction in the education community. Laparoscopic games tend to be serious games due to the nature of the surgery and the realistic platform used. There are rarely questions banks, solution feedback, or inherent competition; they appear to be simulation games used to teach technical skills to the residents. Presumably, the residents can use in-house equipment, similar to the laparoscopic simulators being developed for specialties like general surgery.[23] However, residents can also improve hand coordination and dexterity by using other video-game platforms such as PS4, Switch, and Xbox.[24] It is more practical for residency programs to use serious games to teach surgical skills, and as such, research in simulation games far exceeds that of gamification.

Gamification is adding elements of a game to enhance the efficacy of a platform. The authors have identified a few reasons that could explain the lack of gamification in residency education. The first is the misunderstanding within the medical community of the definition of gamification. It may be difficult to create a consensus around the definition of "gamification" because the literature is heterogenous. The second is the low number of gamification elements within a platform to qualify it as "gamified". Without enough difference between a normal exam or question bank with a solution, a gamified platform will not be as popular or sought after by its users.[3] The number of elements needed to maximize learning and user retention is subjective and unclear. In addition, a high floor of the minimum gamification elements may be too restrictive. The quality of the elements included and the overall functionality of the platform are also important considerations. This review sets the minimum threshold at three, but with more studies, other crucial components can be evaluated as well. The third reason is that gamification as a concept seems to be most effective when used with didactic resources. This review showcases that the most important additions to a question with feedback are as follows: communication between players, added competition, and the inclusion of a basic story line. It is more conducive to add gamification elements to didactic questions rather than a simulation game.

Analysis of the studies demonstrates the main advantage of gamification is user engagement with the content and with other residents. The addition of a story line would add an extra feature to help attract and retain users while not distracting from the original goal of enhancing education. Whereas some studies loosely defined improvement between a control cohort of residents and a cohort that utilized a gamified platform, often the study design did not incorporate or allow for such a comparison. It is unclear whether there is a definitive advantage when learning with a gamified platform compared with a traditional lesson structure. This review highlights that an average of four gamification elements was added in each study.

Due to the lack of literature and consensus on the definition of "gamification," the authors recommend that more gamification studies be conducted to continue to develop the idea of what elements are needed to enhance residency education. In addition, surveys may be sent to residents and residency programs to gauge interest in both gamification and identify their place in the future of residency education. This will help determine what should be prioritized in future

gamification studies. Maximizing gamification elements within a platform would require participation of multiple disciplines during the developmental phases of the game. Faculty would provide the questions/didactic content. A detailed story line can be created by video-game developers, with residents selected to test the platform to ensure the appropriate gamification elements were included and the story line does not distract from the main purpose of education.

Finally, the authors recommend the medical community push for a cogent definition of "gamification." The utilization of gamification possesses significant promise. More research will allow a better understanding of gamification's role within residency medical education.

5 | CONCLUSION

Review of the current literature found that the medical field has limited research regarding the use of gamification in educational platforms. The main limitation of this review is the scarcity of gamification research which includes three or more elements within the medical field including otolaryngology. Despite many simulation studies and attempts at gamification, the medical community has not fully embraced gamification within residency education. As the application of serious games within medical surgery education is appreciated as an increasingly useful method for learning both the basic and advanced surgical techniques, the authors support continued development of prototypes by surgical specialties to teach the necessary skills.

In closing, the medical education community should establish a definition of "gamification" and survey residency programs to identify desired gamification elements. This should allow the medical education community to decide how best to incorporate gamification into residency education.

ACKNOWLEDGMENT

CONFLICT OF INTEREST
The authors declare that are no outside sources of funding and no conflicts of interest.

ORCID
Zack K. Westenhaver https://orcid.org/0000-0002-0666-6394
Robert E. Africa https://orcid.org/0000-0001-6408-3077
René E. Zimmerer https://orcid.org/0000-0002-1180-2039
Brian J. McKinnon https://orcid.org/0000-0002-2257-4721

REFERENCES
1. Looyestyn J, Kernot J, Boshoff K, Ryan J, Edney S, Maher C. Does gamification increase engagement with online programs? A systematic review. *PLoS One*. 2017;12(3):e0173403. doi:10.1371/journal.pone.0173403

2. Alexander D, Thrasher M, Hughley B, et al. Gamification as a tool for resident education in otolaryngology: a pilot study. *Laryngoscope*. 2019;129(2):358-361. doi:10.1002/lary.27286

3. Cugelman B. Gamification: what it is and why it matters to digital health behavior change developers. *JMIR Serious Games*. 2013;1(1):e3. doi:10.2196/games.3139

4. Höchsmann C, Infanger D, Klenk C, Königstein K, Walz SP, Schmidt-Trucksäss A. Effectiveness of a behavior change technique-based smartphone game to improve intrinsic motivation and physical activity adherence in patients with type 2 diabetes: randomized controlled trial. *JMIR Serious Games*. 2019;7(1):e11444. doi:10.2196/11444

5. Brigham TJ. An introduction to Gamification: adding game elements for engagement. *Med Ref Serv Q*. 2015;34(4):471-480. doi:10.1080/02763869.2015.1082385

6. Dankbaar ME, Roozeboom MB, Oprins EA, et al. Preparing residents effectively in emergency skills training with a serious game. *Simul Healthc*. 2017;12(1):9-16. doi:10.1097/SIH.0000000000000194

7. El-Beheiry M, McCreery G, Schlachta CM. A serious game skills competition increases voluntary usage and proficiency of a virtual reality laparoscopic simulator during first-year surgical residents' simulation curriculum. *Surg Endosc*. 2017;31(4):1643-1650. doi:10.1007/s00464-016-5152-y

8. Brar G, Lambert S, Huang S, Dang R, Chan TM. Using observation to determine teachable moments within a serious game: a GridlockED as medical education (GAME) study. *AEM Educ Train*. 2021;5(2):e10456. doi:10.1002/aet2.10456

9. Bridges EP, Foster CE, Park DB, Lehman-Huskamp KL, Mark DW, Tuuri RE. Learning to beat the shock clock: a low-Fidelity simulation board game for pediatric and emergency medicine residents. *MedEdPORTAL*. 2019;15:10804. doi:10.15766/mep_2374-8265.10804

10. Jalink MB, Goris J, Heineman E, Pierie JP, ten Cate Hoedemaker HO. The effects of video games on laparoscopic simulator skills. *Am J Surg*. 2014;208(1):151-156. doi:10.1016/j.amjsurg.2013.11.006

11. Sanko JS, Gattamorta K, Young J, Durham CF, Sherwood G, Dolansky M. A multisite study demonstrates positive impacts to systems thinking using a table-top simulation experience. *Nurse Educ*. 2021;46(1):29-33. doi:10.1097/NNE.0000000000000817

12. McAuliffe JC, McAuliffe RH, Romero-Velez G, Statter M, Melvin WS, Muscarella P. Feasibility and efficacy of gamification in general surgery residency: preliminary outcomes of residency teams. *Am J Surg*. 2020;219(2):283-288. doi:10.1016/j.amjsurg.2019.10.051

13. Nevin CR, Westfall AO, Rodriguez JM, et al. Gamification as a tool for enhancing graduate medical education. *Postgrad Med J*. 2014;90(1070):685-693. doi:10.1136/postgradmedj-2013-132486

14. Kerfoot BP, Baker H. An online spaced-education game to teach and assess residents: a multi-institutional prospective trial. *J Am Coll Surg*. 2012;214(3):367-373. doi:10.1016/j.jamcollsurg.2011.11.009

15. Lin DT, Park J, Liebert CA, Lau JN. Validity evidence for surgical improvement of clinical knowledge ops: a novel gaming platform to assess surgical decision making. *Am J Surg*. 2015;209(1):79-85. doi:10.1016/j.amjsurg.2014.08.033

16. Wu X, Peterson RB, Gadde JA, Baugnon KL, Mullins ME, Allen JW. Winter is here: a case study in updating the neuroradiology didactic curriculum through a Gamification of thrones solution. *J Am Coll Radiol*. 2020;17(11):1485-1490. doi:10.1016/j.jacr.2020.05.028

17. Minkowitz S, Leeman K, Giambrone AE, Kherani JF, Belfi LM, Bartolotta RJ. Emergency radiology "boot camp": educating emergency medicine residents using E-learning radiology modules. *AEM Educ Train*. 2017;1(1):43-47. doi:10.1002/aet2.10002

18. Webb TP, Simpson D, Denson S, Duthie E. Gaming used as an informal instructional technique: effects on learner knowledge and satisfaction. *J Surg Educ*. 2012;69(3):330-334. doi:10.1016/j.jsurg.2011.10.002

19. Jirasevijinda T, Brown LC. Jeopardy!: an innovative approach to teach psychosocial aspects of pediatrics. *Patient Educ Couns*. 2010;80(3):333-336. doi:10.1016/j.pec.2010.06.002

20. Kerfoot BP, Kissane N. The use of gamification to boost residents' engagement in simulation training. *JAMA Surg*. 2014;149(11):1208-1209. doi:10.1001/jamasurg.2014.1779

21. Hvolbek AP, Nilsson PM, Sanguedolce F, Lund L. A prospective study of the effect of video games on robotic surgery skills using the high-fidelity virtual reality RobotiX simulator. *Adv Med Educ Pract*. 2019; 10:627-634. doi:10.2147/AMEP.S199323

22. Fanning J, Fenton B, Johnson C, Johnson J, Rehman S. Comparison of teenaged video gamers vs PGY-I residents in obstetrics and gynecology on a laparoscopic simulator. *J Minim Invasive Gynecol*. 2011;18(2): 169-172. doi:10.1016/j.jmig.2010.11.002

23. Adams BJ, Margaron F, Kaplan BJ. Comparing video games and laparoscopic simulators in the development of laparoscopic skills in surgical residents. *J Surg Educ*. 2012;69(6):714-717. doi:10.1016/j.jsurg.2012.06.006

24. Krause W, Bird J, Cullinane DC. The importance of robotic-assisted procedures in residency training to applicants of a community general surgery residency program. *J Robot Surg*. 2019;13(3):379-382. doi: 10.1007/s11701-018-0859-5