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# Winter Is Here: A Case Study in Updating the Neuroradiology Didactic Curriculum Through a Gamification of Thrones Solution

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## DESCRIPTION OF THE PROBLEM

Engaging and effectively educating learners is a long-standing issue in graduate medical education [1]. We noted a decrease in resident attendance and focus during our daily traditional didactic curriculum. Although there is protected resident conference time, attendance is difficult to verify because of videoconferencing. Trainees are motivated to learn by a variety of factors, including intrinsic intellectual curiosity, desire to excel, examinations, and clinical rotations [1]. However, these can be undermined by competing clinical or research demands, learners' variable interests in the subject, and perception of its relevance for clinical practice or examinations [1].

Even if trainees recognize value in the curriculum, presentation styles may affect effective learning. Passive learning, in which knowledge is gained purely through listening and watching without instructor feedback, is limited in efficacy [2]. Active learning, in which learners participate in the discovery process, can increase information retention [2]. However, it may be difficult to implement active learning in residency curricula [1]. A major barrier is lack of "buy-in" (ie, learners are not motivated by

active learning methods and view them as pointless) [1].

There is increasing interest in gamification and its effect on engagement and buy-in [3]. Theoretically, gamification increases participant motivation by endowing them with "epic purpose" [3]. By framing educational goals as a contest, gamification offers immediately attainable challenges and consistent rules against which accomplishments are rewarded through positive feedback [4]. Gamification encourages teamwork, because players have implicitly agreed to the same rules and goals [4]. For medical education, gamification has shown promising results in participant acceptance and knowledge retention [5].

Mindful of increasing engagement, we redesigned our resident neuroradiology curriculum by updating lecture contents and gamifying the delivery method. Our main objectives were to increase resident awareness, attendance, and participation by redefining high-yield didactic topics and encouraging healthy competition.

## WHAT WE DID

A major determinant of participant buy-in of a gamified system is alignment of participant and game-designer goals [3]. Given changes in the ABR

Initial Certification, we redesigned our current curriculum based on neuroradiology topics within the ABR "Diagnostic Radiology CORE Examination Study Guide" [6]. Main study guide topics were divided into conferences to be repeated on a 2-year cycle to ensure redundancy. Advanced topics, considered beneficial by faculty but not part of the study guide, were repeated every 4 years (Table 1). Each faculty member was asked to participate by teaching at least one conference yearly. We made the curriculum available to residents, highlighting correlations with the study guide [6] to alleviate concerns that chosen topics were solely centered around faculty interest.

Curriculum gamification was based on the popular HBO television show *Game of Thrones*, in which powerful families vied for political and military dominance [7]. Residents were divided into four houses (Lannisters, Targaryens, Starks, and the Night's Watch [7]), balanced across different postgraduate-year levels, subspecialty interest, and gender (Table 2). House assignments were made by a Clinical Competency Committee faculty member familiar with residents' clinical interests. Each house elected a leader (king or

**Table 1.** Redesigned neuroradiology residency lecture curriculum developed based on the ABR CORE Examination Study Guide [6]

Main Topics (Every 2 y)	Advanced Topics (Every 4 y)
<b>Brain</b>	
Brain anatomy	Neuroradiology and machine learning
Intracranial infections or emergency neuroradiology	Radiogenomics
White matter inflammatory or demyelinating disease	Spine interventions
Traumatic brain injury	Fetal MRI
Adult intracranial neoplasms	
Cerebrovascular disease or stroke	
Intracranial hemorrhage	
Increased and decreased intracranial pressure	
Aging and neurodegeneration	
Midline structures (including sella and pineal space)	
Neurovascular anatomy, vasculitis, aneurysms and AVMs	
<b>Spine</b>	
Spine anatomy and degenerative changes	
Spine trauma	
Neoplastic disease of the spine	
Inflammatory, infectious, and vascular disease of the spine	
<b>Head and neck</b>	
Overview of head and neck anatomy and emergencies	
Sinonasal cavities and orbits	
Temporal bone anatomy and pathology, include IAC or CPA	
Skull base, cranial nerves, and CSF leak	
Calvarium, facial bones, mandible, and TMJ	
Salivary glands and aerodigestive tract	
Cervical adenopathy and visceral space	
<b>Pediatric neurology</b>	
Epilepsy, metabolic and toxic brain injury	
Hydrocephalus, intracranial cysts	
Pediatric neuroradiologic emergencies and nonaccidental injury	

(continued)

**Table 1.** Continued

Main Topics (Every 2 y)	Advanced Topics (Every 4 y)
Pediatric headache and back pain	
Congenital brain and spine malformations	
Pediatric seizure disorder and phakomatoses	
Pediatric inherited metabolic and white matter disorders	
Pediatric brain and spine neoplasms	
Artifacts in neuroradiology	
Advanced techniques in neuroimaging	

AVM = arteriovenous malformation; CPA = cerebellopontine angle; CSF = cerebrospinal fluid; IAC = internal auditory canal; TMJ = temporomandibular joint.

queen), who encouraged team members to respond to questions and online campaigns and arbitrated differing responses. Teams sat together during each conference.

Each conference lecturer divided 20 points among the houses as they liked, based on attendance, multiple-choice responses, free response, anatomic drawing, and individual or group problem-solving. Faculty were encouraged to use creative challenges to maximize active learning and supported with resources including interactive slide deck templates (such as *Jeopardy!*), active learning ideas (including reversed-classroom teaching

or drawing exercises), and polling software (including Poll Everywhere [8], Kahoot! [9], and RSNA Diagnosis Live [10]), which were accessible on a dedicated intranet site. Administrative support was provided for the translation of existing lectures into interactive formats. Faculty were familiarized with the gamified curriculum before implementation with collaborative discussions facilitated by the sectional education committee and received regular e-mail reminders throughout the year to sustain utilization of gamification techniques.

Twice a year, residents participated in “campaigns” worth 50 points

each. These were open-book, online case-based challenges coupled with questions regarding imaging findings, diagnosis, and management. Each king or queen solicited and submitted a consensus response for their house, and the 50 points were divided by the faculty organizer among the houses based on accuracy of their responses. Each house’s score was periodically posted on a highly trafficked, secure resident website to remind learners of their progress. At graduation, the winning house was honored with a “crowning ceremony,” and their banner was hung in the residency conference room as a visual challenge to

**Table 2.** Demographic breakdown of the houses in 2019 to 2020 based on gender, postgraduate year, and potential interest in neuroradiology from R2-R4 residents

Demographic	Stark (%)	Lannister (%)	Night Watch (%)	Targaryen (%)
Male	68.8	68.8	68.8	66.7
Female	31.3	31.3	31.3	33.3
R1	31.3	25.0	31.3	26.7
R2	25.0	25.0	25.0	20.0
R3	25.0	25.0	18.8	26.7
R4	18.8	25.0	25.0	26.7
Estimate interest in neuroradiology (R2-R4)	50.0	36.4	40.0	33.3

R1, residency year 1; R2, residency year 2; R3, residency year 3; R4, residency year 4.

**Table 3.** Institutional review board–exempt, anonymized survey questions assessing self-reported resident attitudes toward the old, as well as redesigned neuroradiology curricula

Question	Possible answers
Which year of residency are you in?	R1, R2, R3, R4
Are you aware that a predetermined neuroradiology lecture curriculum exists?	Yes, no
How organized is the neuroradiology lecture curriculum?	1: very disorganized, 2: disorganized, 3: neither organized or disorganized, 4: organized, 5: very organized
How much does the neuroradiology lecture curriculum prepare you for your rotations, call, and clinical practice?	1: not useful at all, 2: somewhat not useful, 3: neither useful or not useful, 4: useful, 5: very useful
How well does the neuroradiology lecture curriculum prepare you for the CORE examination?	1: not well at all, 2: not well, 3: neither well or not well, 4: well, 5: very well
Are you aware that there is an ABR outline for the topics tested on the CORE examination?	Yes, no
If yes to the previous question, have you ever read through the outline?	Yes, no
If yes to the previous questions, how well does the neuroradiology lecture curriculum match the topics shown on the outline?	1: not well at all, 2: not well, 3: neither well or not well, 4: well, 5: very well
How often do you attend the neuroradiology noon lectures in person?	0%, 1%-25%, 26%-50%, 51%-75%, 76-99%, 100%
When you do not attend a neuroradiology lecture in person, how often do you watch it remotely?	0%, 1%-25%, 26%-50%, 51%-75%, 76%-99%, 100%
Please rank your reasons for not attending neuroradiology lectures, where 1 = most frequent reason.	<ul style="list-style-type: none"> <li>■ Too busy on a clinical rotation; have to finish dictating cases to leave on time</li> <li>■ What's happening on rotation is more interesting than the lecture topic, even if I'm not required to stay (eg, rare procedure)</li> <li>■ The lecture topic is not interesting</li> <li>■ The lecturer is not interesting</li> <li>■ Inconvenient location</li> <li>■ Webcasting not working</li> <li>■ I've heard this lecture before and do not feel like I need it again</li> <li>■ Other</li> </ul>
How well do you retain information presented in neuroradiology lectures?	1: not well at all, 2: not well, 3: neither well or not well, 4: well, 5: very well
How much redundancy is built into the neuroradiology curriculum?	<ul style="list-style-type: none"> <li>■ Not enough—I hear things once and do not remember it well enough</li> <li>■ Barely enough—I vaguely remember hearing something before, but could probably use more repetition</li> </ul>

(continued)

Table 3. Continued

Question	Possible answers
	<ul style="list-style-type: none"> <li>■ Just right—I feel comfortable with the amount of reinforcement offered by repeated lectures</li> <li>■ A little too much—I feel myself getting bored occasionally by materials I recognize</li> <li>■ Way too much—I realized I've seen a lecture before and I completely zone out</li> </ul>

R1, residency year 1; R2, residency year 2; R3, residency year 3; R4, residency year 4.

motivate residents during the following academic year.

Before and after the first year of the gamified curriculum's implementation, we performed an anonymized, voluntary, institutional review board-exempt online survey to assess resident attitudes and their attendance habits (Table 3). All 61 residents (residency years 1-4) were surveyed, and questions were predominantly phrased using 5-point Likert scale or true-or-false formats. Results were compared across the two time points with statistical significance assessed by the Mann-Whitney *U* test.

## OUTCOMES AND LIMITATIONS

Before implementation, 22 of 61 (36%) residents responded to the survey and 25 of 61 (41%) responded afterward. Significant differences were found in awareness of the existence of a neuroradiology curriculum (increasing from 18% to 76%,  $P = .0007$ ), and the number of residents who thought the curriculum was "organized" or "very well organized" ( $P = .005$ ). No significant differences were found in how well residents believed the curriculum prepared them for rotations, call, or CORE examination. However, a greater percentage of learners believed that the redesigned curriculum prepared them "well" or "very well" as compared with before. None of the other questions

yielded statistically different results. An informal evaluation of neuroradiology in-service examination results from 2016 to 2020 did not show significant differences in performance trends before and after curriculum gamification, although this assessment may be underpowered given high individual and postgraduate-year class variability.

Our intervention altered both content and delivery method of the curriculum, making it difficult to distill the impact of each of these changes. However, because there was no change in residents' awareness of the ABR study guide [6] or their perception of how closely the curriculum mimicked it, it is likely that these outcomes are at least partly attributable to gamification. We refrained from asking leading questions regarding self-perceived engagement and enjoyment of the curriculum. However, marketing research suggests that increasing awareness forms the baseline step toward increasing customer engagement. Thus, improved awareness of the gamified curriculum and perception of its organization may pave way for better engagement.

A challenge of gamifying the curriculum is the ability and willingness of faculty members to alter lecture styles toward active learning. We were fortunate to have a faculty with high levels of interest in educational improvement, and we easily filled the schedule with teachers eager to

give multiple conferences. Informal faculty feedback indicated that the centralized intranet resource with applications and templates encouraged creativity, and administrative support helped decrease associated technological challenges. Though regular reminders were necessary to encourage uniform utilization of gamification techniques (such as appropriate point assignments), most faculty successfully adopted active learning techniques.

This questionnaire is limited by the subjectivity of self-reporting and self-selection, in which attendance and information retention can be over-reported. Our sample size is limited by voluntary participation from a single year of residents. The non-independent, unpaired sample population may have also undermined statistical power, limiting ability to detect significant changes in resident attitudes.

In the future, we plan to improve objective tracking of resident engagement, including attendance. Because the recent coronavirus disease 2019 pandemic necessitated remote learning, it has become easier to monitor attendance and participation as residents now individually log in. The gamified curriculum can also be brought out of the lecture hall by allowing teams to earn points during the clinical workday. Through innovative approaches to educational

strategy including gamification, we hope to continue improving the quality of radiology education.

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The authors state that they have no conflict of interest related to the material discussed in this article. Dr Wu, Dr Peterson, Dr Gadde, Dr Baugon, Dr Mullins and Dr Allen are nonpartner, non-partnership track employees.

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