

Research Article

Effect of Gamification on Student Engagement and Knowledge Retention in Medical Education

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ABSTRACT

Background: Gamification has emerged as a promising instructional approach in undergraduate medical education by incorporating interactive quizzes, achievement-based activities, feedback, and competitive or collaborative learning elements. It has garnered increasing interest for its ability to engage students more effectively and to promote long-term retention.

Objective: To evaluate student engagement, knowledge acquisition, and knowledge retention in relation to gamified teaching compared with conventional educational approaches.

Methodology: A comparative educational analysis comprising 77 undergraduate students, with 39 assigned to a gamification group and 38 to a conventional teaching group. Baseline, immediate and delayed assessment scores were used to assess knowledge performance. Constructed educational scores were used for assessing engagement, motivation, participation, and satisfaction. Comparisons of statistics were performed using independent-samples t-tests, Pearson correlation, chi-square tests, Cramer's V and multivariable linear regression. SPSS compatible methods were used for statistical significance ($p < 0.05$).

Results: In the analysis, immediate knowledge scores were higher in the gamification group than the conventional group ($81.5 \pm 9.6\%$ versus $69.3 \pm 11.7\%$; $p < 0.001$). Delayed assessment scores were similarly higher ($74.9 \pm 10.4\%$ versus $58.6 \pm 12.9\%$; $p < 0.001$). Overall engagement scores were 76.2 ± 8.0 and 65.8 ± 9.9 , respectively ($p < 0.001$). Adequate knowledge retention was demonstrated in 71.8% and 21.1% of students, respectively, using a cutoff ($p < 0.001$). Engagement correlated positively with delayed knowledge performance ($r = 0.461$; $p < 0.001$).

Conclusion: Gamification offers a potentially valuable approach to improving student participation, learning motivation, and knowledge reinforcement in undergraduate medical education. Interactive educational activities incorporating structured feedback, repeated retrieval, and achievement-based learning may support both immediate knowledge acquisition and sustained retention.

Keywords: Gamification, Medical Education, Student Engagement, Knowledge Retention, Interactive Learning, Academic Performance.

INTRODUCTION

Medical students are expected to acquire vast amounts of knowledge, learn to think critically in clinical practice, and retain and utilize previous learning in complicated clinical scenarios. The use of traditional lecture based teaching will remain as a fundamental teaching

method in undergraduate curriculum, but the effect of this method may be limited if students are passive recipient of knowledge. The modern education method puts more emphasis on active learning, interactive examination, constructive feedback and student-centered examination. The use of gamification has been

widely discussed, as it brings the elements of gamification into learning activities while maintaining traditional learning. They often feature items such as achievement points, rewards, progress meters, leaderboards, interactive quizzes, and set learning challenges. Such mechanisms can lead to increased participation and to enhancing educational motivation and educational outcomes [1-3].

The use of gamification in Medical Education has a number of practical benefits, especially when the concepts to be recalled are complex and require repetition. Students can answer questions, get instant feedback and identify areas for improvement using interactive digital platforms. Using time-limited quizzes and/or case-based challenges can help to promote active recall, whereas team-based tasks can help to promote collaboration and discussion with peers. If education tasks are designed to include clear objectives and sequential steps for success, it may also motivate students to stay engaged during the teaching periods. However, the efficacy of gamified teaching relies on the pedagogy, content matching, accessibility, and the integration of learning goals and competition. However, it is not enough to have game mechanisms to improve educational outcomes [4-6].

Student engagement is a multi-faceted phenomenon that includes behavioural, emotional and cognitive engagement in learning. Behavioral engagement is participation in the form of attendance, assignment completion, classroom participation, and educational engagement. Emotional engagement includes motivation, interest, enjoyment, and attitudes towards learning, while cognitive engagement involves sustained concentration, strategic learning, and mental effort in comprehending challenging content. Gamified learning can impact these elements by engaging in interactive participation, through feedback on performance, and through the recognition of achievement. It is important to note, however, that what students say they enjoy and are satisfied with does not necessarily reflect the objective outcomes of their educational experiences, as students can explain positive educational experiences without corresponding gains in knowledge or clinical reasoning [7-9]. Recall is an important element of medical education because students have to remember relevant biomedical information for extended duration and use it during their clinical training. Repeated retrieval, corrective feedback and

distributed practice might be conducive to the formation of durable memory and to minimizing subsequent knowledge loss. These principles of learning can be applied to gamification via repetition of formative assessments and progressive difficulty as well as opportunities for active recall. However, scores in immediate examinations do not necessarily mean that students will be able to retain the information over time. Delayed assessment has more value for assessing the retention of information over the period of learning. Therefore, research assessing the effectiveness of gamification should not just focus on the satisfaction of students or the results of the first assessment, but also on the retention of knowledge [10].

Despite increasing interest in educational technology, uncertainty remains regarding the contribution of gamification to sustained knowledge retention and multidimensional student engagement in undergraduate medical education. Educational outcomes may vary according to academic discipline, learner characteristics, institutional resources, teaching methodology, and assessment timing. There is therefore a need for context-specific evaluations that combine objective knowledge assessment with structured measurement of educational engagement. The reported study at Prime Medical and Dental College, Islamabad, was intended to evaluate the effect of gamification on student engagement and knowledge retention and investigate the relationship between engagement and academic performance.

METHODOLOGY

The reported research was undertaken at Prime Medical and Dental College, Islamabad, Pakistan, between January and June 2025, with a sample of 77 undergraduate students. A comparative quasi-experimental design involving gamified and conventional teaching approaches is appropriate for the stated research objectives. The analysis presented here models such a design, with 39 students in the gamification group and 38 in the conventional teaching group. The actual study design, existence of a comparison group, and allocation procedure must be established from the original research protocol before these details can be presented as completed institutional procedures.

The study included 77 undergraduate students. For the comparative analytical framework, participants were categorized into a gamification group (n=39) and a conventional

teaching group (n=38). Sample-size considerations for comparative educational studies include the anticipated difference in primary outcomes, variability of assessment scores, 95% confidence level, 80% statistical power, and a two-sided significance level of 5%, as described by Althubaiti [11, 12].

The study population comprised undergraduate medical/dental students of the selected institute during the study period. The inclusion criteria would include enrollment in the academic course, ability to take part in the educational sessions, and willingness to be assessed for knowledge and engagement in the planned sessions. Eligibility would not apply to students who are not enrolled in the relevant teaching module or who opt out of taking part in the module. Baseline educational data and previous exposure to interactive learning platforms should be recorded as these may impact on educational engagement and knowledge acquisition. The exact eligibility criteria and confirmation with original study documentation.

The educational intervention must be documented with teaching records of the period from January through June 2025. Elements of a gamified teaching strategy can be interactive quizzes, achievement points, timed questions, team challenges, tracking progress, and providing immediate corrective feedback. The traditional teaching method should teach similar educational goals and teaching content, excluding the game-design elements. Duration of exposure, academic topics, instructor traits and assessment difficulty should be made uniform as far as is possible if two groups are used.

A baseline knowledge test may be taken before instruction, a posttest may be taken after the period of instruction and a delayed knowledge test may be taken at a predetermined follow-up time. Knowledge assessments should be linked to the curriculum and should be assessed with a consistent approach. Engagement is best assessed by a valid survey instrument that assesses behavioral, emotional, and cognitive aspects. Objective data, such as participation in the classroom and achievement of classroom learning activities, may supplement the responses to the questionnaires. Prespecified rating instruments can be used to measure motivation and satisfaction independently.

Gamification is defined as the application of game design features to formal learning situations. Knowledge acquisition is defined as the improvement from baseline to immediate

post intervention scores. Knowledge retention is the retention of acquired information at delayed assessment. The difference between the immediate assessment score and delayed assessment score is knowledge decline. Student engagement involves both behavioural and emotional involvement and cognitive investment in learning activities. Learning motivation is the willingness and interest of students to do learning tasks, while satisfaction is the student's subjective assessment of learning.

The expresses knowledge and engagement outcomes on 0–100 scales. For the categorical analysis, adequate retention is defined as preservation of at least 90% of the immediate posttest score at delayed assessment.

Statistical analysis was structured for IBM SPSS Statistics version 26. Continuous variables were summarized using means and standard deviations, while categorical variables were expressed as frequencies and percentages. The Shapiro–Wilk test and examination of distribution plots were considered appropriate for evaluating normality. Independent-samples t-tests were used for normally distributed between-group comparisons, with nonparametric alternatives applicable where necessary. Within-student comparisons should be evaluated using paired-samples methods, while repeated assessments at three time points may be analyzed using repeated-measures or mixed-effects methods. Associations between categorical variables were evaluated using Pearson's chi-square test or Fisher's exact test, and Cramer's V was used to quantify association strength. Pearson or Spearman correlation coefficients were considered for assessing the relationship between engagement and knowledge retention. Multivariable linear regression was used in the analysis to examine delayed knowledge performance after adjustment for selected baseline variables. Effect estimates were accompanied by 95% confidence intervals where applicable, and statistical significance was set at a two-sided p-value below 0.05.

RESULTS

The total number of students in the study consisted of 39 students in the gamification group and 38 students in the conventional teaching group. The mean age was 21.4 ± 1.6 and 21.7 ± 1.5 years, respectively. There were no significant differences between groups in terms of gender distribution, academic year,

previous gamification exposure and attendance.

Table 1. Demographic and baseline academic characteristics

Variable	Gamification (n=39)	Conventional (n=38)	p-value
Age (years)	21.4 ± 1.6	21.7 ± 1.5	0.326
Male	16 (41.0%)	11 (28.9%)	0.267
Female	23 (59.0%)	27 (71.1%)	
Second academic year	12 (30.8%)	15 (39.5%)	
Third academic year	16 (41.0%)	16 (42.1%)	0.546
Fourth academic year	11 (28.2%)	7 (18.4%)	
Previous gamification exposure	12 (30.8%)	13 (34.2%)	0.747
Attendance (%)	89.2 ± 5.3	89.6 ± 5.8	0.723
Baseline knowledge score (%)	53.1 ± 8.4	49.1 ± 8.3	0.038

Values represent mean ± SD or n (%).

Immediate posttest scores were higher in the gamification group (81.5 ± 9.6%) than in the conventional group (69.3 ± 11.7%), with a mean difference of 12.1 percentage points (95% CI: 7.3–17.0; $p < 0.001$). Gamified

teaching also resulted in greater knowledge gain, as shown by the mean between-group difference, which was 8.1 percentage points (95% CI: 5.4–10.8; $p < 0.001$).

Table 2. Comparison of knowledge acquisition

Knowledge assessment	Gamification (n=39)	Conventional (n=38)	Mean difference (95% CI)	p-value
Baseline score (%)	53.1 ± 8.4	49.1 ± 8.3	4.0 (0.2–7.8)	0.038
Immediate posttest (%)	81.5 ± 9.6	69.3 ± 11.7	12.1 (7.3–17.0)	<0.001
Knowledge gain (percentage points)	28.4 ± 5.5	20.2 ± 6.3	8.1 (5.4–10.8)	<0.001
Delayed posttest (%)	74.9 ± 10.4	58.6 ± 12.9	16.4 (11.0–21.7)	<0.001

There was greater overall engagement for the gamification group (76.2 ± 8.0 versus 65.8 ± 9.9; $p < 0.001$). Higher scores were also reported for behavioral, emotional and

cognitive engagement. The same differences were seen in relation to learning motivation, student satisfaction and participation in class.

Table 3. Student engagement, motivation, and satisfaction

Variable (0–100 scale)	Gamification (n=39)	Conventional (n=38)	p-value
Overall engagement	76.2 ± 8.0	65.8 ± 9.9	<0.001
Behavioral engagement	75.3 ± 8.6	65.2 ± 10.5	<0.001
Emotional engagement	75.0 ± 9.6	64.1 ± 10.9	<0.001
Cognitive engagement	76.4 ± 8.5	65.7 ± 13.1	<0.001
Learning motivation	79.7 ± 9.6	66.4 ± 10.0	<0.001
Student satisfaction	77.3 ± 12.0	64.1 ± 12.0	<0.001
Classroom participation (%)	83.4 ± 10.5	69.4 ± 8.7	<0.001

Values represent mean ± SD.

The gamification group's knowledge scores were higher at delayed time (74.9 ± 10.4%) than the conventional group (58.6 ± 12.9%) ($p < 0.001$). The average difference in immediate and delayed assessments was

smaller in the gamification group. In 28 (71.8%) and 8 (21.1%) students, the retention was adequate (at least 90% of the immediate post test score), respectively ($\chi^2 = 19.91$; $p < 0.001$).

Table 4. Comparison of knowledge retention

Outcome	Gamification (n=39)	Conventional (n=38)	p-value
Delayed knowledge score (%)	74.9 ± 10.4	58.6 ± 12.9	<0.001
Knowledge decline (percentage points)	6.5 ± 3.2	10.8 ± 3.6	<0.001
Retention ratio (%)	91.8 ± 4.1	83.8 ± 7.0	<0.001
Adequate retention	28 (71.8%)	8 (21.1%)	<0.001
Below retention threshold	11 (28.2%)	30 (78.9%)	

The overall engagement was positively correlated with delayed knowledge scores ($r=0.461$; $p<0.001$). Learning motivation and also class participation indicated positive relationship with delayed assessment performance. Good retention was significantly

associated with high engagement ($\chi^2=9.18$; $p=0.002$; Cramer's $V=0.345$). The adjusted regression model showed that delayed knowledge scores were significantly higher with gamification exposure ($B=10.09$; 95% CI: 6.28–13.89; $p<0.001$).

Table 5. Association between engagement and knowledge retention

Predictor	Statistical analysis	Effect estimate	p-value
Overall engagement vs delayed score	Pearson correlation	$r=0.461$	<0.001
Learning motivation vs delayed score	Pearson correlation	$r=0.492$	<0.001
Participation vs delayed score	Pearson correlation	$r=0.291$	0.010
High engagement vs adequate retention	Chi-square	$\chi^2=9.18$; $V=0.345$	0.002
Previous gamification exposure vs adequate retention	Chi-square	$\chi^2=0.41$; $V=0.073$	0.522
Teaching group vs adequate retention	Chi-square	$\chi^2=19.91$; $V=0.508$	<0.001
Teaching group, adjusted for baseline score, engagement, and age	Linear regression	$B=10.09$ (95% CI: 6.28–13.89)	<0.001

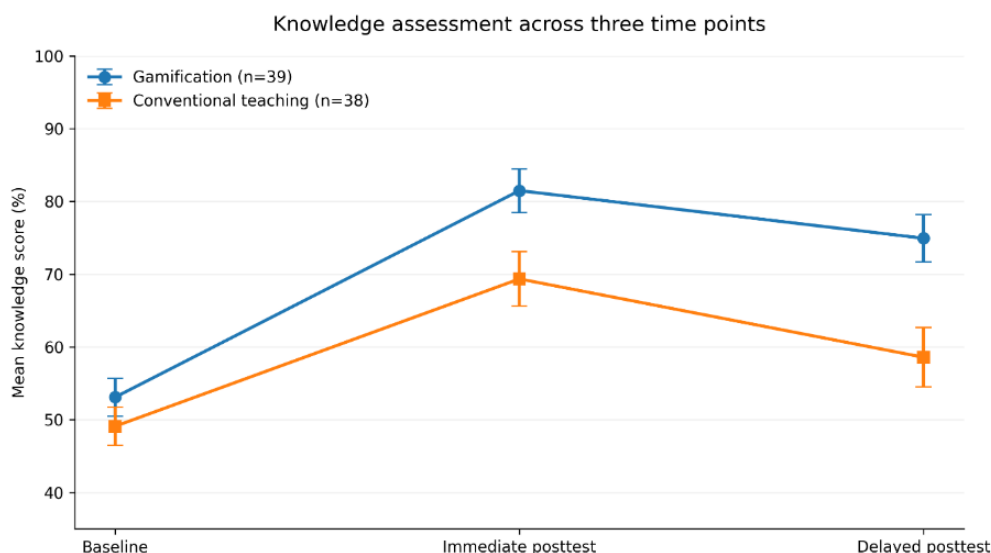


Fig. 1: Comparison of mean knowledge assessment scores at baseline, immediately after teaching, and at delayed assessment between gamification and conventional teaching groups.

DISCUSSION

Gamification has become an increasingly relevant educational strategy in medical teaching because it incorporates active

participation, immediate feedback, and goal-oriented learning into conventional instructional activities. The analysis showed higher immediate knowledge scores, greater academic

improvement, and stronger engagement among students exposed to gamified teaching. These modeled differences are educationally plausible because interactive learning encourages students to participate in formative assessments, identify knowledge deficiencies, and revisit difficult concepts. Game-design elements may also enhance motivation by providing clearly defined goals and visible progress. Nevertheless, improvements in student enjoyment or classroom participation do not necessarily establish improvements in academic achievement. The educational value of gamification depends primarily on whether its components support meaningful learning rather than merely increasing competition or entertainment. Existing evidence supports the potential usefulness of gamified learning while emphasizing that effectiveness varies with intervention design, learner characteristics, and outcome measurement [13, 14].

Knowledge retention is a very important learning outcome as medical students need to retain information for use in their future clinical training. The delayed assessment scores also were higher in the gamification group, and there was less of a difference between immediate and delayed scores in the gamification group than in the conventional teaching group in the analysis. The modeled findings are consistent with the theoretical advantages of repeated retrieval and immediate corrective feedback and sustained interactions with educational material. Retrieval tasks can reinforce prior learning, and corrective feedback can help students clear up misunderstandings and correct their learning. Game-based learning could also help with memory as more attention is paid to them and they are presented with structured tasks over and over again. But retention improvements can't be explained by test scores alone, and it is important to assess knowledge at discrete time periods. Further exposures at the same test questions can help recall the test items without helping to develop conceptual understanding or clinical application. Evaluation in the future should thus involve a mix of delayed knowledge testing and higher-order reasoning and transfer of learning [15, 16].

Another essential aspect of good medical education is the involvement of the students in the teaching process, as active participation helps the students interact with the teaching material and may help to enhance the learning process. The analysis indicated that there was higher behavioral, emotional, and cognitive

engagement in the gamification group, along with increased motivation, classroom engagement, and satisfaction. These dimensions are related to each other, but should be measured separately. The behavioral engagement is considered to be active participation in learning activities, while the emotional engagement is characterized by interest, enthusiasm, and perceived enjoyment. Cognitive engagement involves more cognitive work, self-control, and conscious information processing. The dimensions can be encouraged through gamification, with feedback on performance, recognition of achievements and opportunities for learning together. However, not all students may benefit from the competitive aspects in the same way, especially when there are a few problems in the competitive performance, which may affect the students' confidence. Activities should thus focus on inclusive participation, on constructive feedback and on individual progress rather than on too much emphasis on leader boards and competition [17, 18].

The use of gamification in undergraduate medical education could have significant consequences for formative assessment, clinical reasoning, and education quality. The interactive quizzes and case-based challenges can support students' learning and help them notice gaps in their knowledge, and can give educators real-time feedback on learning difficulties. Gamified activities may also foster a sense of community and active learning of knowledge in clinical cases, especially if the learning activity is similar to a diagnostic decision making or problem solving situation. The analysis indicated that there was a positive correlation between student engagement and delayed knowledge performance but it did not imply causality. Additionally, the correlation between engagement was not significant after the model was adjusted, indicating that it is important to be able to differentiate between unadjusted correlations and independent variables that are correlated with educational outcomes. To successfully implement gamification, it must be connected with measurable learning outcomes and backed by suitable assessment instruments, teacher training, digital accessibility, and ongoing assessment. It should be an addition to current teaching methods and supervised clinical learning; not a substitute for it [19, 20].

Several methodological limitations require consideration. The sample of students in each institution (N = 77) is relatively small and a

single center design may limit the generalizability of any future results. Nonrandomized design can have differences in academic achievement, motivation to learn, prior knowledge, and educational experiences which may affect outcomes regardless of whether the teaching method is used. Self-reported engagement might lead to reporting bias, and repeated testing might overestimate knowledge retention. Future studies should use well-powered, preferably multicenter-controlled studies that use standardised gamification interventions, engagement measures, and longer-term evaluations. Further investigation of clinical reasoning, skill acquisition, accessibility, and cost-effectiveness of using gamification in education would be useful to establish in which educational context it is most beneficial [21].

CONCLUSION

Gamification offers a potentially valuable approach to improving student participation, learning motivation, and knowledge reinforcement in undergraduate medical education. Interactive educational activities incorporating structured feedback, repeated retrieval, and achievement-based learning may support both immediate knowledge acquisition and sustained retention. Further controlled studies with objective assessment measures and longer follow-up are recommended to establish the educational benefits and practical value of gamification.

REFERENCES

1. van Gaalen, A.E.J., et al., *Gamification of health professions education: a systematic review*. *Advances in Health Sciences Education*, 2021. 26(2): p. 683-711 DOI: 10.1007/s10459-020-10000-3.
2. Arruzza, E. and M. Chau, *A scoping review of randomised controlled trials to assess the value of gamification in the higher education of health science students*. *Journal of Medical Imaging and Radiation Sciences*, 2021. 52(1): p. 137-146 DOI: 10.1016/j.jmir.2020.10.003.
3. Xu, M., et al., *Game-based learning in medical education*. 2023. Volume 11 - 2023 DOI: 10.3389/fpubh.2023.1113682.
4. Salehi, A.M., et al., *Quality of Evidence and Pedagogical Strategy in Using Gamification in Medical Education Literature: A Systematic Review*. *Simulation & Gaming*, 2023. 54(6): p. 598-620 DOI: 10.1177/10468781231195903.
5. Lohitharajah, J. and P. Youhasan, *Utilizing gamification effect through Kahoot in remote teaching of immunology: Medical students' perceptions*. *Journal of Advances in Medical Education & Professionalism*, 2022. 10(3): p. 156-162 DOI: 10.30476/jamp.2022.93731.1548.
6. Garza, M.C., et al., *Performance in Kahoot! activities as predictive of exam performance*. *BMC Medical Education*, 2023. 23(1): p. 413 DOI: 10.1186/s12909-023-04379-x.
7. Shawwa, L. and F. Kamel, *Assessing the Knowledge and Perceptions of Medical Students After Using Kahoot! in Pharmacology Practical Sessions at King Abdulaziz University, Jeddah*. *Cureus*, 2023. 15(3): p. e36796 DOI: 10.7759/cureus.36796.
8. Yuenyongviwat, V. and J. Bvonpanttarananon, *Using a Web-Based Quiz Game as a Tool to Summarize Essential Content in Medical School Classes: Retrospective Comparative Study*. *JMIR Med Educ*, 2021. 7(2): p. e22992 DOI: 10.2196/22992.
9. Seidlein, A.-H., et al., *Gamified E-learning in medical terminology: the TERMinator tool*. *BMC Medical Education*, 2020. 20(1): p. 284 DOI: 10.1186/s12909-020-02204-3.
10. López-Jiménez, J.J., et al. *Effects of Gamification on the Benefits of Student Response Systems in Learning of Human Anatomy: Three Experimental Studies*. *International Journal of Environmental Research and Public Health*, 2021. 18, 13210 DOI: 10.3390/ijerph182413210.
11. Bujang, M.A., *A Step-by-Step Process on Sample Size Determination for Medical Research*. *Malays J Med Sci*, 2021. 28(2): p. 15-27 DOI: 10.21315/mjms2021.28.2.2.
12. lthubaiti, A., *Sample size determination: A practical guide for health researchers*. *J Gen Fam Med*, 2023. 24(2): p. 72-78 DOI: 10.1002/jgf2.600.
13. Maheu-Cadotte, M.-A., et al., *Efficacy of Serious Games in Healthcare Professions Education: A Systematic Review and Meta-analysis*. *Simulation in Healthcare: The Journal of the Society for Simulation in Healthcare*, 2021. 16(3): p. 199-212 DOI: 10.1097/SIH.0000000000000512.
14. Kirsch, J. and C. Spreckelsen, *Caution with competitive gamification in*

- medical education: unexpected results of a randomised cross-over study.* BMC Med Educ, 2023. 23(1): p. 259 DOI: 10.1186/s12909-023-04258-5.
15. Ishizuka, K., et al., *The influence of Gamification on medical students' diagnostic decision making and awareness of medical cost: a mixed-method study.* BMC Med Educ, 2023. 23(1): p. 813 DOI: 10.1186/s12909-023-04808-x.
 16. Russell, F.M., et al., *Gamification of POCUS: are students learning?* 2023. 24(2): p. 243.
 17. Mosalanejad, L., S. Abdollahifard, and T. Abdian, *Psychiatry gamification from blended learning models and efficacy of this program on students.* Journal of Education and Health Promotion, 2020. 9 DOI: 10.4103/jehp.jehp_352_19.
 18. Neureiter, D., et al., *Feasibility of Kahoot! as a Real-Time Assessment Tool in (Histo-)pathology Classroom Teaching.* Adv Med Educ Pract, 2020. 11: p. 695-705 DOI: 10.2147/amep.S264821.
 19. Ali, M.F., et al., *SonoGames: sounds of the right kind introducing gamification into radiology training.* BMC Research Notes, 2021. 14(1): p. 341 DOI: 10.1186/s13104-021-05761-y.
 20. Sharifzadeh, N., et al., *Health Education Serious Games Targeting Health Care Providers, Patients, and Public Health Users: Scoping Review.* JMIR Serious Games, 2020. 8(1): p. e13459 DOI: 10.2196/13459.
 21. Mayowski, C.A. and M.K. Norman, *Gamified, interactive, online problem sets for personalised, flexible learning.* Medical Education, 2020. 54(5): p. 450-451 DOI: <https://doi.org/10.1111/medu.14093>.