JHCE$_{in}$P

From compliance to engagement. Using Gamification to promote "Quality and Risk culture" in a University Hospital[1].

Claudio Pensieri[1]; Rossana Alloni[2]

[1]*LUMSA- Libera Università Maria S.s. Assunta, RM;* [2]*Direttore clinico, Fondazione Policlinico Universitario Campus Bio-Medico, Roma*

Abstract: Continuous professional development is essential but often limited by heavy workloads and low motivation, especially for transversal topics such as clinical risk management and quality systems. Gamification has emerged as an effective strategy to enhance engagement in adult education. This study describes the "Campus Game 2022," a gamified training program implemented in a University Hospital in Rome to improve knowledge and awareness of quality and safety practices. In 2022, 18 teams (145 participants) competed weekly in a digital quiz featuring multiple-choice questions on hospital policies and safety protocols. Drawing on Social Comparison and Reinforcement Learning theories, the program included leaderboards, feedback loops, rewards, and "badge challenges" that encouraged hands-on learning in areas like hand hygiene, emergency evacuation, and data protection. Engagement remained high over 25 weekly rounds, with 15 teams completing all challenges. The average participation rate was 76.8% (p=0.0012). ANOVA showed significant differences in participation between matchdays (F=36.57, p<0.0001), and a decline was noted in the second half, likely due to external factors such as the summer break and scoring dynamics. Gamification proved to enhance motivation, collaboration, and active learning in healthcare education, particularly for cross-disciplinary, non-clinical topics. Further research should explore its long-term impact and scalability.

Key-words: medical education, quality & safety, risk management, resident orientation.

---

[1] Il lavoro è il risultato di una progettazione, di una ricerca e di una discussione condivise. La stesura dei paragrafi è da attribuire come segue: §§ 1, 2, 3 e 4 Claudio Pensieri; Supervisione e §§ 5 Rossana Alloni; Conclusioni, redatte congiuntamente dagli autori.

Introduction

Professional training is a rapidly evolving system across all professional sectors.

However, not all professional sectors are the same. The healthcare field, for example, is a sector where doctors, nurses, and healthcare personnel work continuously, often facing long shifts and alternating day/night schedules.

If staying up to date and undergoing training is already challenging in most professional fields, it becomes even more difficult in the healthcare sector.

An additional challenge is that they need a training on non-motivating topics - those not directly related to one's specific discipline - such as training on Quality and Clinical Risk Management (QCR). To achieve our corporate training objectives and meet the international accreditation standards set by the Joint Commission International, we have chosen to incorporate Gamification dynamics into our corporate training programs.

The application of gamification to risk management and quality management education for practicing registered nurses and doctors represents an emerging area of healthcare professional development. While gamification has gained considerable attention in medical education broadly (Gentry, 2019), specific research focusing on continuing education for working healthcare professionals in risk and quality management remains limited.

Evidence has shown that a commitment-based, intrinsically motivated approach to change is more successful and sustained over time than a compliance-based (e.g., mandated) approach (Bevan, 2022). Gamification engages the user, provides a level of enjoyment, and incentivizes the learner to use critical thinking skills. However, the use of gamification (the application of game design and elements) as a clinical engagement strategy in health quality improvement initiatives is less explored (McKeown, 2016).

This synthesis examines the available evidence on gamification techniques, their effectiveness, implementation strategies, and success factors in this specialized context.

This paper is a case history about a gamification experience used as an innovative method for continuing education on the QCR training at Fondazione Policlinico Universitario Campus Bio-Medico (FPUCBM) in Rome, Italy.

Medical education has witnessed significant advancements in recent years, driven by technological advancements and a growing emphasis on learner-centered approaches. Mohsen et al. (2023) reviewed modern techniques of teaching and learning in medical education. Their review synthesizes relevant literature to provide an overview of innovative instructional methods, such as simulation-based training, flipped classrooms, problem-based learning, and digital platforms. They discuss the benefits and challenges associated with these techniques and highlights the need for faculty development to effectively implement and integrate them into medical training.

The permanent training of adult professionals is a constant challenge: everyone is convinced that it is necessary to update and resume notions and principles already known, but very few people do this in a constant and organized way (Pensieri et al., 2023)

Gamification, the application of game-design elements in non-game contexts, has been explored as a strategy to enhance the education and training of healthcare professionals.

It is used in order to engage audiences and inject a bit of fun into mundane activities as well as to generate motivational and cognitive benefits.

This study aims to explore the potential of gamification as a strategy to enhance professional training in the healthcare sector, specifically in the context of Quality and Clinical Risk Management education.

Our hypothesis is that gamification alone may not be sufficient to improve cognitive learning outcomes, but when combined with practical challenges, feedback mechanisms, and team-based competition, it can enhance both motivation and knowledge retention.

Our main questions are:

1)   Does gamification increase motivation and participation in non-discipline-specific training among healthcare professionals?

2)   Does it lead to better knowledge retention and application compared to traditional training approaches?

The underlying hypothesis is that gamification leads to higher levels of engagement and improved training outcomes among healthcare professionals than conventional instructional methods. However, given existing mixed evidence in the literature, this study also considers whether gamification alone is sufficient or if it requires integration with other pedagogical strategies - such as practical challenges and feedback systems - to effectively enhance learning and knowledge retention. In fact, the only gamification application may be riskly, a research by Wang & Tahir (2020) examined the effects of using game-based learning platforms, such as Kahoot!, in classroom settings.

Their findings suggest that while these tools can boost student motivation and engagement (Malicki, 2020), they do not always lead to a significant improvement in learning performance. This indicates that, although gamification can make learning more engaging and enjoyable, its impact on cognitive learning outcomes may be limited. In other words, motivation and participation increase, but that doesn't automatically mean better retention or deeper understanding of the material.

While gamification tends to activate extrinsic motivational levers (rewards, visual progress, competition), which can stimulate initial engagement (greater participation in concrete or experiential tasks, faster execution, better practical application) if designed superficially, may not foster these skills: it risks shifting the focus to the playful objective rather than conceptual learning that can lead to lower performance on written tests or less "substantive" participation in discussions (Huang, 2024).

So it has to be designed with a clear alignment between game mechanics and learning objectives, integrated with moments of reflection and feedback.

If gamification remains a simple "aesthetic layer of gameplay," it is likely to produce the effects described (Li, 2023).

For instance, a study by Domínguez (2013) found that students participating in gamified experiences achieved higher scores in practical assignments but performed poorly on written tasks and class participation. This suggests that while gamification can boost initial motivation, its overall effect on learning outcomes requires careful consideration.

For this reason, in our last Campus Game we applied also practical Badges, and practical challenges.

We also stimulated every team in studying the answers and we invited them to appeal to Clinical Management court if some answers were not right for them.

From a long time in nursing education, the use of serious games has been investigated to prepare students for real-world scenarios. Petit dit Dariel (2013) highlighted that such games offer a safe environment for students to develop essential skills (Reed, 2020), particularly in home-care and community settings where traditional clinical exposure may be lacking. These simulations have been shown to improve knowledge acquisition, critical thinking, and the ability to identify deteriorating patients.

Innovative approaches and modalities for education in health professions education are constantly sought to improve teaching and learning and ultimately patient care and outcomes. Digital education may be one such innovation (Gentry 2019).

However, the successful implementation of gamification in healthcare education requires thoughtful design and integration.

The Gentry review (2019) suggests that serious gaming may have the potential to advance education by improving knowledge, and possibly skill, outcomes for health professions compared with traditional learning. It may be able to provide educational interventions that are of equivalent educational value to other kinds of digital education, but with improved learner satisfaction. If this approach is equivalent to other kinds of education in terms of outcome but more cost-effective or able to offer greater access, it may provide further reasons to recommend serious gaming/gamification interventions, but no studies assessing these factors were identified.

Evidence has shown that a commitment-based, intrinsically motivated approach to change is more successful and sustained over time than a compliance-based (e.g., mandated) approach.

Gamification engages the user, provides a level of enjoyment, and incentivizes the learner to use critical thinking skills. Multiple studies (Van Gaalen, 2021) reported that the frequently used combination of assessment and conflict/challenge game attributes could increase the use of gamified learning materials, strengthen satisfaction or improve learning outcomes.

Gamification, like other forms of e-learning, offers the advantage of making the updating of educational materials more flexible, since digital content can be modified continuously and more easily than printed textbooks (Gentry, 2019).

However, while updating the content is relatively simple, adapting or redesigning the game mechanics themselves is often more complex, as it requires additional testing, calibration and maintenance. This distinction is especially relevant in medical education, where both content and instructional design must evolve in parallel with rapidly changing clinical guidelines.

Starting from the work of Van Nuland (2015) and Chen (2017), two theoretical perspectives have been widely used to explain how gamification may influence learning: Social Comparison Theory and Reinforcement Learning Theory.

Van Nuland (2015) draws on Social Comparison Theory, which describes social comparison as a fundamental mechanism through which individuals evaluate their knowledge and adjust their behaviour (Festinger, 1954; Corcoran, 2011). In this model, gamification elements such as leaderboards are intended to help learners identify discrepancies in their knowledge through upward comparison, or validate their existing assumptions through downward comparison. According to Van Nuland, these mechanisms can enhance performance by making learners more aware of their strengths and weaknesses. Nevertheless, competitive mechanics such as leaderboards may also have unintended effects: while they can increase engagement in some learners, they may reduce participation or motivation in others, particularly those who perceive competition as anxiety-inducing or discouraging. This asymmetry is especially relevant in medical education, where collaboration and reflective reasoning are often as important as performance.

Chen (2017), instead, interprets gamification through the lens of Reinforcement Learning Theory, a behavioural framework where learning is shaped by rewards and punishments (Börgers & Sarin, 1997). In this approach, receiving points, badges or positive feedback serves as reinforcement that increases the likelihood of repeating a desired behaviour, while negative cues—such as red-coloured responses—act as punishments that reduce unwanted behaviours. In digital learning environments, such mechanisms can enhance learners' subjective experience and support the acquisition of procedural or implicit skills. However, reinforcement-based mechanics tend to be more effective for repetitive or automatizable tasks, and are not always sufficient to promote higher-level cognitive processes such as clinical reasoning, integration of concepts or reflective judgment—competencies that are crucial in medical training.

Overall, both theories provide meaningful frameworks for understanding why gamification may influence learner behaviour. Yet they also highlight limitations: competitive comparison and reinforcement dynamics can support motivation and procedural learning but do not automatically translate into deeper, conceptual understanding. For this reason, the integration of gamification in medical education requires careful pedagogical design to ensure that game mechanics align not only with engagement goals but also with the cultivation of complex clinical competencies.

Some application of Gamification in professionalism training are:

1) The CLABSI App bundled line care best practices with social gamification and microlearning, engaging 105 unique nurses in 673 self-assessments over 12 months (Orwoll, 2018). The application incorporated competitive elements through interunit competitions, which were associated with increased engagement.

2) Game-based multimedia applications: a randomized controlled trial of 132 nurses using a Comprehensive Geriatric Assessment (CGA) app based on the Octalysis gamification framework demonstrated significantly higher confidence in geriatric care abilities compared to traditional classroom learning (Moser, 2024).

Materials and methods

Since 2018, we have explored gamification as a strategy to enhance clinician engagement in adhering to clinical risk management and quality improvement protocols (Author, 2023). To achieve this, we developed a team-based game where interdisciplinary teams - including doctors, nurses, administrative staff, biologists, and pharmacists - compete weekly to promptly answer three questions related to QCR.

We submitted this project to the Ethics Committee of the University Campus Bio-Medico of Rome which, taking into consideration the fact that no clinical data or sensitive data are recorded, stated that it was not necessary to obtain the informed consent from players and human subjects protections are not applicable.

We structured our game according with the Social Comparison Theory and the Reinforcement Learning Theory.

So, we structured our game in this way: every Monday, we sent a mobile-based form with three questions to all players. Each team had two days to research the correct answers and submit their responses. On Wednesday, we closed the submission window, and after each game, once the deadline had passed, we sent an email to all participants with the correct answers, allowing them to learn from their mistakes. The hospital management incentivized participation by awarding a monetary prize to the winning teams. In opposition with previous tournament, we decided to make public the name of every participant of each team. We decided it because it was suggested to us in the assessment questionnaire we submitted following the CG 2021 edition. The Management of the FPUCBM could not play the game because of conflict of interest.

The game was organized using free Google Forms and consisted of answering 3 multiple choice questions per week about clinical Quality and Safety. Each correct answer was worth 1 point.

We sent the questionnaire with 3 questions every Monday morning at 10.00 am. The deadline to answer the questions was Wednesday morning at 10.00 am. On Thursday afternoon we sent the correct answers to all the participants (whether or not they answered in that game). On Friday morning we published the updated ranking on the hospital intranet website. The average score of each team was then published online on the hospital intranet to increase the sense of competition and teambuilding. From 28th of March to 14th November 2022 we played 25 rounds and submitted 75 questions about different topics, from clinic to administrative (Fig. 1).
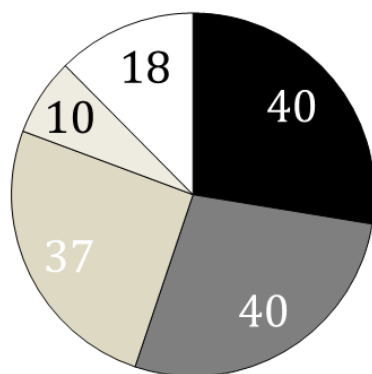
Fig.1 Campus Game timeline

Results

In 2022, 18 teams and 145 players (40 MD, 37 residents, 40 registered nurses, 10 administrative staff, 18 Non-Medical Staff) played the Campus Game 5th edition (Fig. 2) for a total of 25 rounds and 75 questions.

Fig.2 Players

■ MD ■ RN ▨ RES ▢ ADM ▢ Other

During the game, 5 people withdrew from the project, while 1 was replaced by a colleague.

140 employees completed the game, 1 of them answered only one question but he did not ask to withdraw from the game.

The 75 questions were ideated in 10 different areas:

1. Quality and Clinical risk management: 19
2. Prevention and environmental protection: 14
3. Data protection & Privacy: 9
4. Blood Transfusion process: 7
5. Public relations office: 7
6. Hospital Infections Control: 6
7. Guidelines & Procedures: 5
8. Pharmacovigilance: 3
9. Hospital Social Service: 3
10. Human Resources: 2

We introduced Badges to assign scores and move from only-online training to mixed training.
We have therefore planned 4 badges:
a. Teambuilding
b. Evacuation drills
c. Hand hygiene and infections
d. Privacy Data protection

a. Teambuilding

The first badge was about "Teambuilding". Each team had 7 days to create a photo, photocollage or a photomontage of their team. Every team decided to follow one of those possibilities and 15 (on 18) teams participated (Fig. 3). A specific release was not required because the company contract provides permission to use video and photographic material shot within the organization, provided it is used as part of initiatives promoted by the organization. However, out of respect for privacy and the internal purpose of the event, the team images were used exclusively within the hospital and published on the company intranet, avoiding distribution on external channels. We thought that making the names visible, would have encouraged an healthy competition (since the employees of our small hospital know each other) in order to avoid potential negative effects, such as unhealthy competition (Davis, 2024).

Fig.3 Teambuilding challenge

We introduced this badge to raise awareness among the various interdisciplinary teams to know each other and collaborate even more actively.

This challenge was also intended to encourage players from the various teams to meet or to cooperate "in person".

Evaluation: presence/absence of the Team Image.

b. Evacuation drills

We designed this badge to evaluate the "practical" ability to evacuate from the Hospital in the correct way.

Each team had to send the champion representing their own team to the Management Room on the day of the challenge.

Each representative was taken to an area of the hospital (Fig. 4) and, from there, they were asked to evacuate and reach the correct and closest meeting point (Fig. 4). The whole thing was supervised and evaluated by the Security and Protection managers.

Figure 4. Evacuation Challenge

Evaluation: reaching (without assistance from the observer) the correct evacuation point.

c. Hand hygiene and infections

This badge was designed to make healthcare workers aware of their real ability to sanitize their hands. We used a black box with a special sanitizing alcohol solution that highlighted only the areas that were well sanitized and the areas that were sanitized badly (Fig. 5). We decided to not show the

"hand hygiene walkthrough" in order to make the challenge more truthful and practical (as they would normally do in the ward or clinic).

Figure 5. Black-Box Challenge

Evaluation: 80% of well sanitized areas

### d. Privacy Data protection

The last badge we designed was a "timed challenge". Every teams had only one day to answer 10 questions about data management and data protection. In this challenge, every team's player had to answer in the right way in order to gain as many points as possible.

Evaluation: every correct question gave 1 pt. to the team.

Other data

The overall average "Participation Rate" is approximately 76.8%. We can note a high initial participation rate (over 90%) that tended to progressively decline in subsequent matches until reaching 52.1% (Fig. 6).

Figure 6. Participation Rate per Match
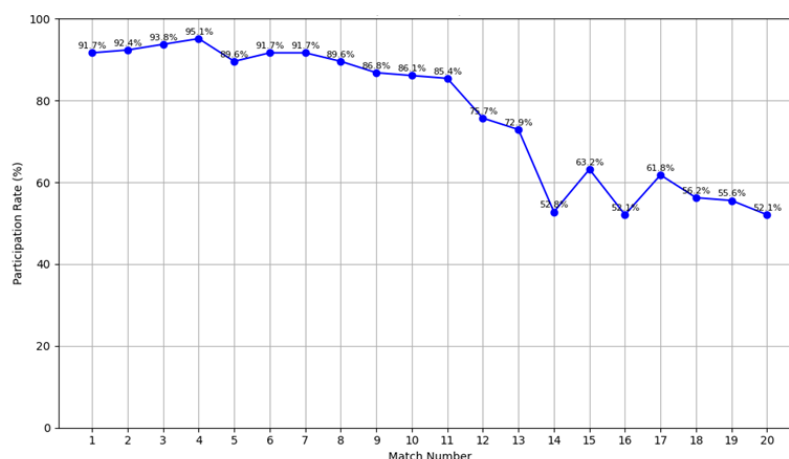
95% confidence interval: (72.74%, 80.87%). This interval tells us that, with 95% confidence, the true mean participation rate lies within this range.

The p-value obtained from the Student t-test (comparing the observed mean participation rate to a hypothetical threshold of 70%) is: 0.0012. This value is much less than 0.05, indicating that the difference between the observed mean and the hypothetical threshold is statistically significant. In other words, it is very unlikely that the mean participation rate is 76% by pure chance.

To assess the distribution of participation rates among players, a Shapiro-Wilk normality test was performed. The test result (statistic = 0.8504, $p < 0.0001$) indicated a significant deviation from normality, suggesting that the data do not follow a symmetrical distribution. This finding is consistent with the qualitative observation of a heterogeneous population, characterized by the presence of both very frequent players and occasional participants, resulting in a skewed distribution and potentially heavy tails. Supporting this interpretation, the standard deviation of the individual participation rate was 24.67%, indicating moderate variability within the analyzed sample. On average, players participated in 76.86% of the games, but this average masks significant differences at the individual level. These results suggest the presence of distinct subgroups of participation behavior within the observed population.

The analysis of variance (ANOVA) conducted on participation rates for each match revealed statistically significant differences between matchdays ($F = 36.57$, $p < 0.0001$), indicating that player participation was not homogeneous over time. Some matches recorded significantly higher participation levels than others, suggesting the presence of contingent factors that influenced participant engagement.

To explore this temporal dynamic, a Mann-Whitney U test was performed, comparing participation rates in the first half of the schedule with those in the second. This result was also statistically significant ($U = 14.627$, $p < 0.0001$), confirming that the two phases of the tournament had different participation profiles. In particular, a decline was observed in the second half, likely attributable to a combination of external factors such as the summer break and the impact of mathematical scoring, which may have influenced player motivation or availability.

The probability that these differences are due to chance is practically zero, strengthening the hypothesis of structural variability in participation behavior throughout the season.

Complaints

We received three formal complaints from two separate teams, specifically from their captains, regarding the correctness of answers to three quiz questions. These teams conducted independent research using scientific literature and subsequently requested a review of the scores we had assigned.

The contested questions pertained to:
— An internal Policy about: "Discharge and transfer to another healthcare structure".
— An internal Policy about: "Patients awaiting the results of sentinel germ surveillance swabs".
— An answer about health data management and privacy.

This feedback is significant and warrants critical examination. On one hand, it may indicate strong engagement, as participants demonstrated initiative by consulting external sources and challenging the content. On the other hand, it may also suggest potential ambiguity in the quiz design, particularly in how questions were framed or how correct answers were determined.

We subsequently analyzed the wording of the three questions together with our Data Protection Officer and we read the internal procedures, concluding that the questions had been properly prepared and that the appeal made by the teams was not entirely relevant to the question asked.

Nonetheless, this outcome aligns with one of our primary objectives: fostering a culture of quality and safety. The use of gamification, rather than traditional lectures, appears to have successfully stimulated interest and active participation in these critical topics.

Discussion

The findings from the 2022 edition of the training project Campus Game highlight the potential of gamification as a valuable tool in the continuing education of healthcare professionals, especially for topics that are often perceived as less engaging, such as clinical risk management, quality assurance, and privacy. The high completion rate - 140 out of 145 participants - and a participation rate of 76,8% suggests that the game mechanics and reward structure (both extrinsic and intrinsic) were effective in maintaining engagement (but not till the end).

The use of interdisciplinary teams further supported cross-functional collaboration, aligning with the initiative's teambuilding objectives.

The design of the intervention aligns with established theoretical frameworks, including Social Comparison Theory (Festinger, 1954) and Reinforcement Learning Theory (Sutton, 2014). Weekly leaderboards and immediate feedback mechanisms appeared to enhance motivation and self-assessment, allowing participants to benchmark their performance and learn from errors (Van Nuland, 2015; Chen, 2017).

The integration of practical "Badge Challenges" also shifted the experience from purely cognitive to experiential learning, fostering hands-on competencies in areas such as infection control and emergency procedures.

This model could be easily replicated by all hospitals committed to a culture of quality and safety. Simply create multiple-choice questions, submit them using any clicker (Google Forms, Wooclap, Mentimeter, Kahoot, etc.), create participation badges, and engage hospital staff in participation (internal communication).

Furthermore, hospital management should offer a series of benefits (preferably financial) to contest winners.

However, while the overall engagement was high, the discussion should acknowledge some key limitation.

Limitations

While the Campus Game project yielded promising results in terms of engagement and participation, several limitations must be acknowledged to contextualize the findings and assess their generalizability.

A notable constraint was the drop in participation during the final rounds, particularly among teams that were mathematically excluded from winning. Five teams ceased participation in the last five rounds, highlighting a common challenge in competitive environments: reduced motivation when the outcome is perceived as unattainable. This underscores the need for more inclusive motivational strategies, such as tiered rewards, milestone-based incentives, or individual recognition, to sustain engagement across all performance levels.

Beyond participation dynamics, the study faced methodological limitations:

1) Absence of a control group: Without a comparative baseline, it is difficult to isolate the effects of gamification from other potential influences on learning or behavior.
2) Lack of pre- and post-intervention assessments: The absence of objective measures of knowledge acquisition limits the ability to quantify educational impact beyond engagement and retention (we have done it in the Campus Game 2023 edition).
3) Potential quiz design ambiguities: The three formal complaints regarding quiz answers, while indicative of cognitive engagement, also suggest possible issues with question clarity and alignment with validated sources. This raises concerns about content validity and the risk of misinterpretation.
4) Evaluation of practical badges: While the practical badges provided hands-on experiences, their evaluation relied primarily on observational or process-based outcomes without standardized performance metrics. Additionally, the use of self-reported data, informal feedback, and internal policies as reference points for quiz questions may have introduced bias or ambiguity, as evidenced by the formal complaints received.
5) Single-site implementation: Conducted in one university hospital in Italy, the findings may not be readily generalizable to other institutions or cultural contexts. Differences in organizational culture, educational norms, and healthcare systems could influence the effectiveness of the gamified model elsewhere (now we are testing it in three different hospitals).

To strengthen future research, it is recommended to replicate the intervention across diverse healthcare settings and incorporate rigorous evaluation methods, including control groups, standardized assessments, and longitudinal follow-up. Exploring the scalability and adaptability of the model could further enhance its utility as a professional development tool. Additionally, addressing the limitations in quiz design and motivational structure will be essential to ensure both validity and inclusivity in future iterations.

Conclusions

Research on gamification for risk and quality management education among practicing healthcare professionals is limited, with most studies focusing on students rather than working nurses and doctors. The available evidence suggests gamification techniques like badge systems, leaderboards, and interactive challenges can improve engagement and knowledge retention, but more rigorous research is needed to establish effectiveness for continuing professional education.

The Campus Game initiative promise potential in promoting compliance with institutional training standards and fostering a learning culture rooted in active participation, critical thinking, and real-world application within healthcare settings. The "Campus Game 2022" project shows that gamification can be a powerful and versatile strategy to support adult education in the quality and risk topics, especially when addressing topics traditionally perceived as non-engaging. By combining digital tools, practical challenges, and team-based competition, the initiative successfully increased participation, fostered interdisciplinary collaboration, and stimulated critical engagement with institutional procedures and safety protocols.

Grounded in principles from Social Comparison Theory and Reinforcement Learning Theory, the use of feedback mechanisms and competitive elements appeared to enhance motivation and reinforce learning behaviors. Importantly, the players' active involvement - evidenced by formal contestations of some quiz contents - suggests a meaningful shift from passive compliance to informed, critical engagement.

However, given the study's limitations - including the absence of a control group, lack of standardized assessments, and single-site implementation - claims regarding the long-term effectiveness and scalability of the model should be approached with caution.

While the results are encouraging, they may not be fully generalizable to other institutions or contexts without further validation.

The positive outcomes suggest that gamified learning models, when thoughtfully designed and contextually adapted, can complement traditional training methods and contribute to a stronger culture of safety, quality, and lifelong learning in healthcare settings.

Future research should aim to assess long-term impacts on knowledge retention and behavioral change and explore scalable models for broader implementation across other hospitals.

Statements and declarations

References

Akl, E.A., Kairouz, V.F., Sackett, K.M., Erdley, W.S., Mustafa, R.A., Fiander, M., Gabriel, C., Schunemann, H. (2013) Educational games for health professionals. *Cochrane Database Syst Rev*. 28;(3): CD006411. doi: 10.1002/14651858.CD006411.pub4. [PMCID: PMC7389433] [PubMed: 23543543].

Amer, R. S., Denehy, G. E., Cobb, D. S., Dawson, D. V., Cunningham-Ford, M. A., & Bergeron, C. (2011). Development and evaluation of an interactive dental video game to teach dentin bonding. *Journal of Dental Education*, 75, 823–831.

Arjoranta, J. (2014). Game definitions: A Wittgensteinian approach. *Game Studies*, 14(1).

Bedwell, W. L., Pavlas, D., Heyne, K., Lazzara, E. H., & Salas, E. (2012). Toward a taxonomy linking game attributes to learning: An empirical study. *Simulation and Gaming*, 43, 729–760.

Bevan, H.; Fairman, S. (2014) The New Era of Thinking and Practice in Change and Transformation: A Call to Action for Leaders of Health and Care. *National Health Service Improving QualityWebsite*. 2014. Available online: https://www.researchgate.net/publication/313478861_The_new_era_of_thinking_and_practice_in_c hange_and_transformation_Improving_Quality_NHS (accessed on 22 August 2022).

Borgers, T., & Sarin, R. (1997). Learning through reinforcement and replicator dynamics. Journal of Economic Theory, 77, 1–14

Borro-Escribano, B., Martinez-Alpuente, I., Blanco, A. Del, Torrente, J., Fernandez-Manjon, B., Matesanz, R. (2013). Application of game-like simulations in the Spanish Transplant National Organization. *Transplantation Proceedings*, 45, 3564–3565.

Caillois, R. (1961). *Man, play, and games*. New York: Schocken Books.

Chan, W. Y., Qin, J., Chui, Y. P., & Heng, P. A. (2012). A serious game for learning ultrasound-guided needle placement skills. *IEEE Transactions on Information Technology in Biomedicine*, 16, 1032–1042.

Chen, A. M. H., Kiersma, M. E., Yehle, K. S., & Plake, K. S. (2015). Impact of the Geriatric Medication Game® on nursing students' empathy and attitudes toward older adults. *Nurse Education Today*, 35(1), 38–43.

Chen, P. H., Roth, H., Galperin-Aizenberg, M., Ruutiainen, A. T., Gefter, W., & Cook, T. S. (2017). Improving abnormality detection on chest radiography using game-like reinforcement mechanics. *Academic Radiology*, 24(11), 1428–1435.

Corcoran, K., Crusius, J., & Mussweiler, T. (2011). "Social comparison: Motives, standards, and mechanisms". In *Handbook of theories of social psychology*: Volume One.

Davis, K., Gowda, A. H. R., Thompson-Newell, N., Maloney, C., Fayyaz, J., & Chang, T. P. (2024). Gamification, Serious Games, and Simulation in Health Professions Education. *Pediatric Annals*, 53(11), e401-e407. https://doi.org/10.3928/19382359-20240908-06

Deterding, S., Khaled, R., Nacke, L., & Dixon, D. (2011). Gamification: Toward a definition. *Chi*, 12–15.

Dominguez, A.; Saenz-De-Navarrete, J.; De-Marcos, L.; Fernandez-Sanz, L.; Pages, C.; Martinez-Herraiz, J. (2013). Gamifying learning experiences: Practical implications and outcomes. *Computers & Education*, Volume 63: 380-392, ISSN 0360-1315, https://doi.org/10.1016/j.compedu.2012.12.020.

Festinger, L. (1954). A theory of social comparison processes. *Human Relations*. 7 (2): 117–140. doi:10.1177/001872675400700202. S2CID 18918768.

Frederick, H. J., Corvetto, M. A., Hobbs, G. W., & Taekman, J. (2011). The "simulation roulette" game. *Simulation in Healthcare*, 6, 244.

Gentry, S.A., Gauthier, A., L'Estrade Ehrstrom, B., Wortley, D., Lilienthal, A., Tudor Car, L., Dauwels-Okutsu, S., Nikolaou, C.K., Zary, N., Campbell, J., Car J. (2019). Serious Gaming and Gamification Education in Health Professions: Systematic Review. *J Med Internet Res*, 21(3): e12994. doi: 10.2196/12994, PMCID: PMC6458534, PMID: 30920375

Gerard, J. M., Scalzo, A. J., Borgman, M. A., Watson, C. M., Byrnes, C. E., Chang, T. P., et al. (2018). Validity evidence for a serious game to assess performance on critical pediatric emergency medicine scenarios. *Simulation in Healthcare*, 13, 168–180.

Huang, W.D., Loid, V., Sung, J.S. (2024). Reflecting on gamified learning in medical education: a systematic literature review grounded in the Structure of Observed Learning Outcomes (SOLO) taxonomy 2012-2022. *BMC Med Educ*. Jan 3;24(1):20. doi: 10.1186/s12909-023-04955-1. Erratum in: BMC Med Educ. 2024 Feb 1;24(1):104. doi: 10.1186/s12909-024-05067-0. PMID: 38172852; PMCID: PMC10765768.

Huizinga, J. (1955). *Homo Ludens: A study of the play element in culture* (1st ed.). Boston: The Beacon Press.

Klabbers, J. H. G. (2009). Terminological ambiguity: Game and simulation. *Simulation and Gaming*, 40, 446–463.

Li, M., Ma, S., Shi, Y. (2023) Examining the effectiveness of gamification as a tool promoting teaching and learning in educational settings: a meta-analysis. *Front. Psychol.*, 09 October. Sec. Media Psychology, Volume 14 – 2023. https://doi.org/10.3389/fpsyg.2023.1253549

Lim, E. C.-H., & Seet, R. C. S. (2008). Using an online neurological localisation game. *Medical Education*, 42(11), 1117.

Malicki, A., Vergara, F. H., Van De Castle, B., Goyeneche, P., Mann, S., Scott, M. P., Seiler, J., Meneses, M. Z., & Whalen, M. (2020). Gamification in Nursing Education: An Integrative Literature Review. *Journal of Continuing Education in Nursing*, 51(11), 509-515. https://doi.org/10.3928/00220124-20201014-07

Mckeown, S.; Krause, C.; Shergill, M.; Siu, A.; Sweet, D. (2016) Gamification as a strategy to engage and motivate clinicians to improve care. *Healthcare Manag. Forum*, 29, 67–73.

Mohsen, D.M., Fagir, M.H., Dein, D.K.E., Yousif, M.B., Eltagani, M., Atieh, M.A. (2023). Modern techniques of teaching and learning in medical education: A descriptive literature review [Internet]. *J Educ Technol Health Sci*.;10(1):4-7. https://doi.org/10.18231/j.jeths.2023.002

Moser, D.K., Lin C.H., & Hu, F.W. (2024). A game-based multimedia application to improve the ability of clinical nurses to perform geriatric care: A randomized controlled trial. *Nurse Education Today*, 138, 106253. https://doi.org/10.1016/j.nedt.2024.106253

Orwoll, B., Diane, S., Henry, D., Tsang, L., Chu, K., Meer, C., Hartman, K., & Roy-Burman, A. (2018). Gamification and Microlearning for Engagement With Quality Improvement (GAMEQI): A Bundled Digital Intervention for the Prevention of Central Line-Associated Bloodstream Infection. *American Journal of Medical Quality*, 33(1), 21-29. https://doi.org/10.1177/1062860617706542

Pensieri, C.; De Benedectis, A.; De Micco, F.; Saccoccia, S.; Ivziku, D.; Lommi, M.; Alloni, R. (2023). Continuing Education through the Campus Game: A Sustainable Gamification Project to Improve Doctors' and Nurses' Knowledge of Quality and Clinical Risk Management. *Healthcare*, 11, 2236. https://doi.org/10.3390/healthcare11162236PETIT DIT DARIEL, O.J.;

Raby, T.; Ravaut, F.; Rothan-Tondeur, M. (2013). Developing the serious games potential in nursing education. *Nurse Education Today*, 33(12), 1569-1575. https://doi.org/10.1016/j.nedt.2012.12.014

Reed, J.M. (2020). Gaming in Nursing Education: Recent Trends and Future Paths. *Journal of Nursing Education*. 59(7):375-381. doi: 10.3928/01484834-20200617-04

Ramsey, F.P. (1923). *Tractatus Logico-Philosophicus. By Ludwig Wittgenstein*. Mind.

Ruiz, J.G., Mintzer, M.J., Issenberg, S.B. (2006). Learning objects in medical education. *Med Teach.*, 28(7):599–605. doi: 10.1080/01421590601039893.770732257 [PubMed: 17594550]

Salen, K., & Zimmerman, E. (2004). "Rules of play: Game design fundamentals". In *Environment. Cambridge*, Mass: MIT Press.

Stanley, D., & Latimer, K. (2011). "The Ward": A simulation game for nursing students. *Nurse Education in Practice,* 11(1), 20–25.

Suits, B. (1978). *The grasshopper: Games, life and Utopia, Bernard suits*. In Library (Issue 15).

Sutton-Smith, B. (2000). *The Ambiguity of Play*. Cambridge, Mass: Harvard University Press. Harvard University Press.

Sutton, R.S., Bart, A.G. (2014). Reinforcement Learning: An Introduction. Cambridge, Massachusetts, London, England: A Bradford Book, The MIT Press.

Wang, A.I., Tahir, R., (2020). The effect of using Kahoot! for learning – A literature review. *Computers & Education*, Volume 149, https://doi.org/10.1016/j.compedu.2020.103818

Webb, M., & Henderson, B. (2017). Gamification: Student feedback and creation of bespoke board games. *Archives of Disease in Childhood*, 102, A24.

Van Gaalen, A.E.J., Brouwer J., Schonrock-Adema, J. Bouwkamp-Timmer, T., Jaarsma, A. D. C., Georgiadis, J. R. (2021). Gamification of health professions education: a systematic review. *Advances in Health Sciences Education*, 26:683–711 https://doi.org/10.1007/s10459-020-10000-3

Van Nuland, S. E., Roach, V. A., Wilson, T. D., & Belliveau, D. J. (2015). Head to head: The role of academic competition in undergraduate anatomical education. *Anatomical Sciences Education*, 8(5), 404–412.