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ENHANCING NEUROLOGY AND NEUROSCIENCE EDUCATION THROUGH GAMIFICATION: INVESTIGATING ITS APPLICATIONS, CONFRONTING CHALLENGES, AND IDENTIFYING OPPORTUNITIES[1]

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ABSTRACT

As educational methodologies continue to advance, the role of games within these paradigms has undergone significant transformation. The symbiosis of game-based learning and technological advancements has not only become increasingly prevalent but has also contributed to the expansion of scholarly discourse advocating for the application of game-oriented educational techniques. Remarkably, it is a relatively recent development that these methodologies have found their application in the domain of medical education. This paper presents a comprehensive review of the empirical evidence that supports the integration of game-based learning within both undergraduate and graduate medical education, with a specific focus on neurology. Furthermore, it delves into the exploration of the challenges and opportunities associated with the implementation of game-based learning in neurologic curricula. In addition to this, the paper examines the potential applications of such educational strategies in clinical settings. The exploration culminates in a discussion on the promising potential of game-based learning within the field of neurology and neuroscience, suggesting that it may represent a pivotal opportunity that warrants strategic consideration and adoption in these disciplines.

Keywords: Neurologic education, neurology education, neuroscience education, gamification, game-based education.

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INTRODUCTION

The inherent role of play, encompassing various forms of games, has been a fundamental part of our existence since inception (Pavlidis, Markantonatou, 2018). In the realm of education, especially in science, technology, engineering, and math disciplines, game-based learning and the gamification of education have become established methodologies (Mayo, 2009; Li, Tsai, 2013; Hamari, Koivisto, Sarsa, 2014). The notion that gaming and competition are beneficial in the learning process is not alien to medical education, but its application in this field is a relatively recent phenomenon.

In this paper, we conduct an exhaustive review of the evidence supporting the integration of game-based learning in both undergraduate and postgraduate medical education, with a specific focus on neurology. Furthermore, we explore the challenges and opportunities in implementing game-based learning within neurologic curricula and its application in clinical settings. The potential of leveraging game-based learning in neurology and neuroscience represents a significant opportunity that needs exploration and adoption.

BACKGROUND

Game-Based Learning and Gamification of Education: Definitions and Theoretical Foundations

As defined by the Oxford English Dictionary, gamification involves applying typical game elements (like point scoring, competition, rules of play) to other areas, often as an online marketing strategy to boost engagement with a product or service (Kawachi, 2017). This concept also encompasses terms like 'game-based learning' and 'gamification of learning'. From a theoretical standpoint, these methods fall under the broader category of active learning, a progressive educational trend that prioritizes engaging learners and emphasizes the application of knowledge over mere acquisition (Sandrone et al., 2020; King, 1993; Ramnanan, Pound, 2017). This denotes a shift from the traditional, teacher-centered approach of imparting knowledge in a didactic manner to a learner-centered approach.

Applications in Medical Education

The incorporation of game-based learning in medical education isn't entirely novel. Globally, many schools and graduate medical education programs periodically organize quiz shows or similar competitions, albeit often on an ad hoc basis (Nevin et al., 2014). Even a simple neuroscience-themed quiz or poll can serve as an opener or closer for a teaching session. While many of these informal sessions lack substantial data to support their effectiveness or educational studies assessing inter-site validity, there is a burgeoning body of literature advocating the use of game-based learning techniques, aligning with the growing interest in active learning (Sandrone et al., 2020).

A notable example is the internal medicine residency program at Birmingham and Huntsville, which introduced a novel, game-based competitive question-based program. This web-based software delivered daily questions

to participating residents, with an online leaderboard tracking their progress. The program's effectiveness was evaluated based on knowledge retention, participation, and acceptance, showing its potential as an educational enhancement, despite the risk of infringing on residents' free time and possibly affecting their mental health (Nevin et al., 2014).

Moreover, gamification can act as an incentive for participation. In a study involving urology and surgery residents, engagement with a simulator increased significantly when a competition with monetary rewards was introduced (Kerfoot, Kissane, 2014). This suggests that combining gamification with practical tools can significantly enhance learner engagement.

In undergraduate medical education, gamification has been implemented with varied results. In a controlled trial, a gamified module on otorhinolaryngology was compared to a traditional presentation (Lee et al., 2018). Although the gamified approach resulted in higher satisfaction scores, it didn't necessarily translate to better knowledge retention compared to conventional methods. However, other studies, like Granger et al.'s, report improvements in specific skills like critical appraisal through web-based educational games (Granger et al., 2018).

Advancing Neurology and Neuroscience Education through Gamification: Exploring Applications, Addressing Neurophobia, and Harnessing Potential

Neurological education is essential for healthcare practitioners at all levels. The phenomenon of neurophobia, a long-standing challenge in medical education, extends beyond just physicians and trainees (Jozefowicz, 1994; Sandrone et al., 2019). Gamification, with its elements of peer support and competition, holds promise in mitigating neurophobia and enhancing learning in this domain.

Remarkably, gamification does not always necessitate high-tech solutions. A study at the University of Alabama employed a simple, low-tech game for teaching cranial nerves to nursing students, involving guessing terms without visual cues (Weaver, Roche, 2019)[16]. Similarly, the 'Neurological Hat Game' in Paris used a card-based approach to teach neurological semiology to medical students (Garcin et al., 2019). These low-tech approaches, while popular among students, require further research for assessing knowledge retention.

Game-based learning is also expanding into Continuous Medical Education (CME), particularly in stroke education. A pioneering study assigned family physicians and residents to game-based or traditional case-based learning groups, finding similar knowledge outcomes but higher satisfaction in the game-based group (Telner et al., 2010). These findings suggest that gamification can enhance engagement and satisfaction in medical education.

Interactivity and Role-Playing in Educational Gaming

The use of multiplayer role-playing games like MimycX, introduced by the American Association of Colleges of Pharmacy, demonstrates the potential of interactive, case-based virtual adventures in learning (Lam et al.,

2019)[19]. This approach, while initially facing mixed responses, underscores the importance of addressing technical challenges and exploiting educational opportunities in game-based learning.

Challenges and Opportunities in Implementing Gamification in Curricula

Gamification offers diverse applications in neurology education, from simple digital quizzes to complex interactive platforms (Nishihara et al., 2020). The key is aligning game-based tools with learning objectives, whether for training or assessment. However, challenges such as learner compliance, time constraints, and the potential for increased burnout among physicians must be considered. Innovative design solutions and strategic curriculum integration can help mitigate these challenges.

On the faculty side, challenges include the need for training and resource allocation for developing gamified curricula. The potential lack of familiarity with adult learning theories among educators can be addressed by creating and sharing educational resources on platforms like MedEdPORTAL.

The Future of Game-Based Learning in Neurology

To substantiate the efficacy of game-based approaches, further studies with larger sample sizes and controlled environments are needed. These should not only assess immediate learning outcomes but also long-term behavior and results, as outlined in Kirkpatrick's model (Kirkpatrick, Kirkpatrick, 2006). The intersection of neuroscience and game design is evolving (Bajaj et al., 2016), and future research must focus on developing replicable game designs based on robust methodologies. Understanding the dynamics of extrinsic versus intrinsic motivation among learners will be crucial in sustaining engagement across different specialties (De Freitas, 2018; Dicheva et al., 2015).

The Multidisciplinary Impact of Gamification: Bridging Neuroscience and Education

In the intersection of neuroscience and education, notable research has revealed the impact of gamification on brain activity, specifically its ability to deactivate the default mode network, which is typically active during rest or non-cognitive tasks (Howard-Jones et al., 2016). This finding underscores the significance of applying cognitive neuroscience insights to educational methods, including technology-enhanced learning (Howard-Jones, Ott, Van Leeuwen, De Smedt, 2014; McCandliss, 2010). One practical application of this has been the use of oscillatory EEG to monitor attention, motivation, and vigilance in game-based learning contexts (Cowley, Ravaja, 2014), offering novel, research-informed perspectives for neurology education (Sigman, Peña, Goldin, Ribeiro, 2014; Sandrone et al., 2019).

Clinical Advancements Through Gamification

Incorporating elements of gamification in clinical settings has shown diverse benefits such as enhanced satisfaction, motivation, and engagement (Li, Tsai, 2013; Urh, Vukovic, Jereb, Pintar, 2015). This approach has

been particularly effective in rehabilitation, merging gamification with technology to provide adaptable, engaging treatments with real-time feedback. Early experiments with the Wii gaming console in rehabilitation contexts demonstrated significant improvements across various domains (Deutsch et al., 2008). Subsequent applications in stroke rehabilitation using Wii games like Wii Sports and Cooking Mama showed marked improvements in motor function compared to traditional therapy (Saposnik et al., 2010; Saposnik, Mamdani, Bayley, Thorpe, Hall, Cohen, Teasell, 2010). Custom gaming systems and software, such as those using the Leap Motion system, represent the next step in tailored rehabilitation strategies (Harley et al., 2011; Karashanov, Manolova, Neshov, 2016). As the field grows, comprehensive evaluations and meta-analyses are beginning to shed light on the efficacy of these methods (Karamians, Proffitt, Kline, Gauthier, 2019; Stinear, Lang, Zeiler, Byblow, 2020). Future research, with larger samples and more nuanced functional outcomes, is required to fully understand the potential of these game-based, technology-assisted solutions (Sokolov, Collignon, Bieler-Aeschlimann, 2020).

Serious Games in Rehabilitation

Beyond traditional game-based learning, the concept of "serious games" – computer or console games with specific, serious objectives – is gaining traction in rehabilitation, particularly in mental health and neurodegenerative disorders (Fleming, Bavin, Stasiak, Hermansson-Webb, Merry, Cheek, Lucassen, Lau, Pollmuller, Hetrick, 2017; Manera et al., 2017). The emergence of exergames, virtual reality-based movement games for both healthy and pathological populations, is another notable trend (Costa, Vieira, de Oliveira Barbosa, Oliveira, Maillot, Vaghetti, Carta, Machado, Gatica-Rojas, Monteiro-Junior, 2019). Everyday examples of gamification, like step counters and movement reminders from wearable devices, are becoming increasingly common. In the realm of performance-based testing, such as neuropsychological profiling, gamified versions can alleviate issues related to test length and patient boredom (Cerrato, Ponticorvo, 2017).

DISCUSSION and CONCLUSION

The exploration of game-based learning within neurology and neuroscience education highlights a transformative potential in pedagogical approaches. While the integration of such interactive methods with technology has gained momentum, contributing substantially to educational research, its full application in neurology and advanced medical training remains an area ripe for exploration.

A critical observation in the current landscape is the contrast between the common use of interactive techniques, such as quiz games in neurology education, and the relative scarcity of robust empirical data validating their effectiveness. This gap suggests an opportunity for more comprehensive research and development. Collaborative efforts across educational programs are essential in this regard. By pooling resources and insights, the academic community can more effectively develop and assess novel gamification strategies, thereby enriching the educational experience in these specialized fields.

As we look to the future, the potential of game-based learning in neurology and neuroscience is undeniable. It represents a pivotal opportunity to redefine traditional educational methodologies, making learning more engaging, interactive, and, potentially, more effective. However, the journey towards fully realizing this potential will require dedicated research efforts, innovative thinking, and collaborative experimentation.

In conclusion, the integration of game-based learning in neurology and neuroscience education is not just a passing trend but a meaningful evolution in teaching methodologies. The challenge now is to build upon this momentum, rigorously evaluate these methods, and develop a framework that effectively incorporates these innovative strategies into the curricula. With concerted efforts and continued research, game-based learning has the potential to significantly enhance the educational landscape in these critical fields of study.

SUGGESTIONS

Based on the current exploration of game-based learning in neurology and neuroscience education, several recommendations can be proposed to maximize the potential of this innovative educational approach:

- **Enhance Research and Data Collection:** There is a need for more rigorous and comprehensive research to validate the effectiveness of game-based learning in neurology. This research should aim to collect empirical data to support its benefits, focusing on long-term knowledge retention, practical skills acquisition, and overall student engagement.

- **Collaborative Initiatives:** Educational institutions should collaborate to share resources, expertise, and best practices. Such collaboration could include joint research projects, shared digital platforms for game-based learning resources, and inter-institutional workshops or seminars.

- **Integrate Technology Thoughtfully:** While integrating technology in game-based learning, it's crucial to ensure that it serves the educational objectives and enhances the learning experience rather than being a mere novelty. The technology should be accessible, user-friendly, and aligned with the learning outcomes.

- **Customize Games for Targeted Learning:** Develop game-based learning tools that are specifically tailored to the complex concepts of neurology and neuroscience. These tools should be designed to address the unique challenges and learning objectives of these fields.

- **Training for Educators:** Provide training for educators and faculty members in the development and implementation of game-based learning. This training should include techniques for integrating these tools into the curriculum effectively and how to use them to facilitate active learning.

- **Feedback and Continuous Improvement:** Implement a feedback system where students can provide insights into their learning experiences. This feedback can guide the continuous improvement of game-based learning tools and strategies.

- **Assessment Integration:** Incorporate game-based learning into both formative and summative assessment strategies. This integration can provide a more comprehensive understanding of the students' knowledge and skills.

- **Explore Diverse Game-Based Approaches:** Experiment with various types of game-based learning, such as simulations, role-playing, and competitive quizzes, to cater to different learning styles and preferences.

By following these recommendations, educational institutions can better harness the power of game-based learning in neurology and neuroscience, leading to more engaging, effective, and interactive educational experiences.

ETHICAL TEXT

This article adheres to the journal's writing standards, publication principles, research and publication ethics rules, and journal ethical guidelines. The author is responsible for any and all violations related to the article. Since this article was conducted through document analysis, one of the qualitative research methods, it does not require ethical board approval.

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