Review Article

Serious Games in Dentistry: Development and Implementation for Three Use Cases

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Abstract

"Serious Games" are interactive simulations designed for learning, training, or skill development in a playful environment. Their primary purpose is educational, although they can also serve other utilitarian functions. Unlike purely recreational games, Serious Games combine practical scenarios with playful elements to promote specific knowledge or skills in various fields, including dentistry. This article presents the concepts and methodologies underlying these games, including their definitions and educational approaches such as constructivism, cognitivism, and behaviorism. In this context, three Serious Games were developed to enhance knowledge and skills in dentistry. These games cover topics such as the memorization of dental pathologies and medications, the fundamental concepts of partial removable prosthetics, and oral hygiene. Each game is designed to meet a specific educational objective through interactive techniques. A satisfaction survey was conducted to assess the impact on learning.

Keywords: Dental Education; Games

Introduction

In dental education, mastering both technical and theoretical skills is crucial. Serious Games are interactive tools that allow students to train in a simulated and safe environment [1,2]. "Serious Games" are educational games that differ from traditional video games due to their focus on learning objectives. Based on educational theories such as constructivism, cognitivism, and behaviorism, they facilitate active learning. Their development follows specific technical steps and relies on interdisciplinary collaboration to maximize their educational effectiveness. In this study, three Serious Games were developed and implemented to enhance the learning experience of 6th-year dental students [1]. This article explores these games in detail, their design, implementation, and the results of a satisfaction survey conducted among users [3,4]. Literature reviews reveal a promising potential for Serious Games in medical and dental education, but their adoption remains limited. Two key questions arise: what pedagogical strategies are being used, and what is the quality of the evidence supporting their effectiveness? Although they are considered useful, the evidence for their effectiveness remains moderate according to studies assessed using the MERSQI score [5].

Definitions, concepts, and implementation approaches of serious games

Serious Games are defined as games whose primary objective is education or awareness rather than entertainment. They combine game mechanics with specific educational goals [6]. These games are commonly used in the medical field, and more recently in den-

tistry, to promote hands-on learning in a controlled and interactive environment. Serious Games are based on several pedagogical theories, including behaviorism, cognitivism, and constructivism. These theories support the development of educational games that enhance knowledge retention and practical learning [7].

Behaviorism

Learning is reinforced through stimuli and rewards, promoting the retention of concepts (see figure 1).
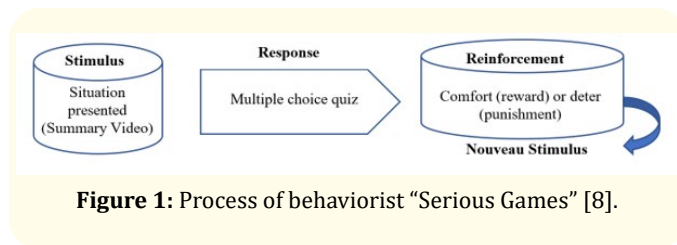
Figure 1: Process of behaviorist "Serious Games" [8].

Cognitivism

Focused on how information is assimilated and stored, this learning model encourages students to solve complex problems.

Constructivism

Students learn through direct experience, by exploring scenarios and actively constructing their knowledge.

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These approaches allow for the adaptation of "Serious Games" to various educational contexts, particularly in dentistry, where practical skills are essential. The creation of "Serious Games" involves expertise in several fields, structured around two main phases: pre-conception and implementation. Figure 4 highlights the key stakeholders involved in the creation process of a "Serious Game." Additionally, there are several forms that a "Serious Game" can take [9]. The most commonly used include: "live" format in a physical setting, "live" digital format, dedicated digital interface for individual or collective connection, and repurposed existing interfaces to integrate "Serious Game" mechanisms. The development of Serious Games requires the use of several technical tools (see Figure 2).

- **Game engines:** "Unity and Unreal Engine" are used to create immersive 3D environments.

- **3D design software**: "Blender and Autodesk Maya" allow for the modeling of dental objects for realistic simulations.

- **Programming languages**: HTML (JavaScript), C++, and Python are the most commonly used for development.

- **Distribution platforms**: Google Play and the App Store facilitate the distribution of "Serious Games".
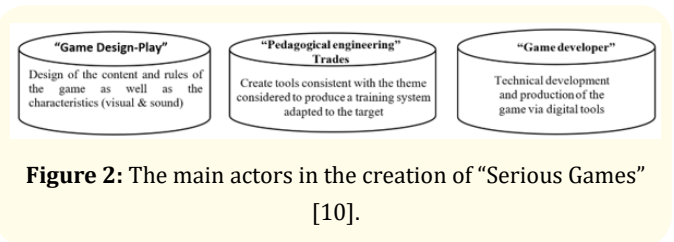
Figure 2: The main actors in the creation of "Serious Games" [10].

Design, development, and implementation of three "serious games" in dentistry

Three Serious Games were specifically developed to meet identified pedagogical needs in dental education. Each game is based on a distinct educational theory and is designed to cover essential areas of clinical training. The design of these Serious Games was intended to be scalable and easily customizable, allowing for content modification simply by changing the text in the code. The games were developed in JavaScript (HTML). The flexibility of the HTML source code facilitated the customization of the educational content. This approach offers maximum flexibility to adapt the games to specific needs, while balancing personalization and scalability. For the development of the "serious games" software, a collaborative approach and the use of open-source resources were prioritized. In this project, the source codes of the various games were developed from open-source codes, adapted, and optimized to meet the specific needs of our doctoral research [10-12]. The games were developed with contribution of two IT engineers [13], in a French version, a bilingual Arabic French version for the "Serious Game - Puzzle: Oral Hygiene (PAP)".

"Serious Game" - Memorization: Pathologies and medications in dentistry (PMD)

This game was designed to help students memorize, on one hand, the most common dental pathologies and, on the other

hand, the medications used in their treatment while providing a safe learning environment where students can repeat exercises as many times as necessary [14]. Additionally, dental practitioners face various clinical cases when it comes to prescribing prophylactic antibiotics, whether for adult or pediatric patients. They must consider potential allergies as well as different routes of administration, whether by injection or orally. Based on behaviorism and framed within cognitivism, this game employs techniques of repetition and reinforcement of active memorization to facilitate the learning of common pathologies and medications, while offering a safe learning environment where students can repeat exercises as often as needed. The integration of memory games into training provides a playful and effective method for developing cognitive skills. These games promote the acquisition and consolidation of knowledge while actively engaging learners, thus constituting an innovative educational tool (see Figure 3).
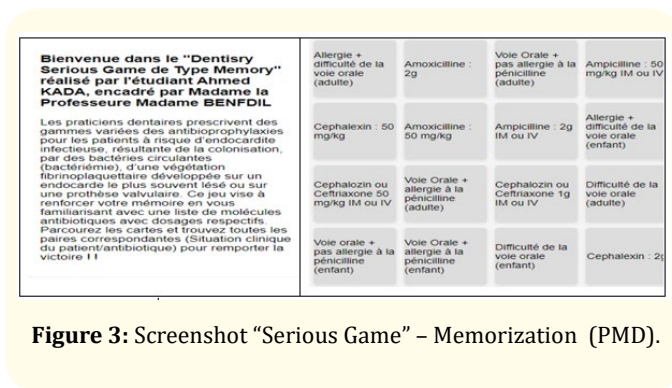

Figure 3: Screenshot "Serious Game" – Memorization (PMD).

Serious Game – Quiz: Fundamental concepts of partial denture prosthesis (PDP)

This Serious Game in PAP, designed for dental education, aims to teach the fundamental techniques of this essential field by simulating the complex procedures of PAP in a virtual environment where students can acquire technical skills in a repetitive and safe manner. Based on the principles of behaviorism, it utilizes a reward system to encourage learning of best practices and operational techniques. Positive reinforcement mechanisms promote the repetition of concepts, while the questions stimulate mental engagement, critical thinking, and problem-solving [15]. Based on multiple-choice questions and an interactive quiz model, this game immerses students in key themes, such as Kennedy-Applegate classification through clinical cases and Cummer classification, allowing them to understand their influence on the design of prostheses.

Students must assemble the components of a virtual partial denture following precise clinical steps, from impression taking to final adjustment. The game provides detailed instructions and real-time feedback on the quality of the assembly and the accuracy of movements, immediately correcting errors to allow students to retry until they succeed. The main objective is to simulate these complex procedures in a secure virtual environment, giving students the opportunity to repeat actions and acquire technical skills with confidence. The game includes interactive quizzes where correct answers trigger positive reinforcement (additional points or levels), while errors encourage replaying. Once the correct answer is given, immediate feedback is provided with detailed explanations (see Figure 4).
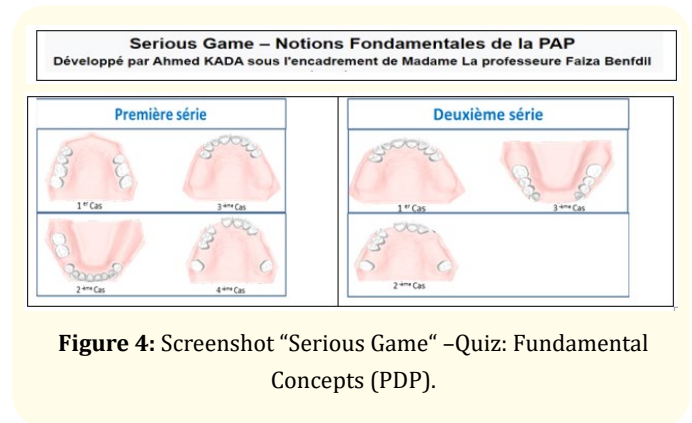

Figure 4: Screenshot "Serious Game" –Quiz: Fundamental Concepts (PDP).

Presentation of the Features of the "Serious Game - Puzzle: Oral Hygiene (PDP)"

This game was developed to raise awareness and educate elderly individuals about good oral hygiene practices, particularly those who have not had regular dental check-ups. Drawing inspiration from existing games, it employs mechanisms based on the principles of behaviorism, promoting learning through repetition and positive reinforcement. It teaches the importance of oral hygiene through an interactive and playful approach [16]. The concept of the Serious Game innovatively integrates a message of awareness and education. An effective strategy is to reward players when they successfully complete a phase of the game, thereby establishing a direct link between gameplay and the information conveyed. The game offers an interactive model in the form of puzzles, where players reconstruct sentences related to oral hygiene advice from jumbled words. Each correct answer triggers a reward in the form

of practical tips, reinforcing player engagement and motivation. This system encourages the repetition of exercises and the learning from mistakes, with immediate correction and explanations to guide users toward the correct answer. The behaviorist approach allows for the solidification of good dental hygiene practices in players' minds by providing a safe environment to experiment and progress. This game also raises awareness of the consequences of bad habits, such as smoking or poor diet (see Figure 5).
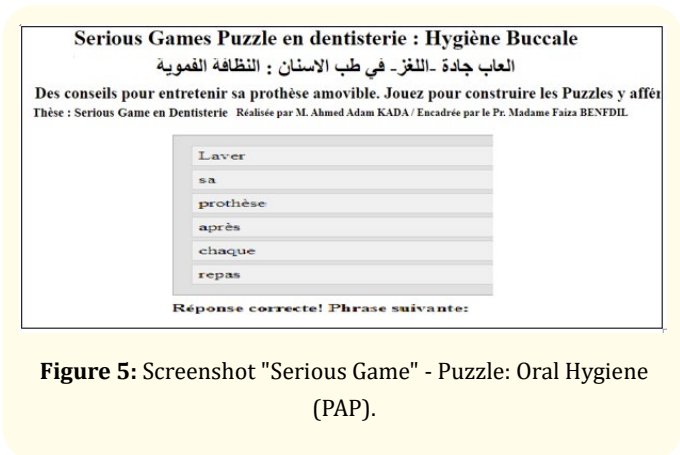

Figure 5: Screenshot "Serious Game" - Puzzle: Oral Hygiene (PAP).

Satisfaction survey

The objective of this satisfaction survey is to evaluate the experience of sixth-year students at the Faculty of Dental Medicine in Rabat with the "Serious Games" developed as part of this work, by determining their satisfaction and the educational impact of these interactive tools. Although previous studies have shown that "Serious Games" can enhance engagement and knowledge retention in medicine, few have focused on their application in dentistry, highlighting the necessity of this research. The survey is based on three games: the "Serious Game - Memorization: Pathologies and Medications in Dentistry (PMD)", the "Serious Game - Fundamental Concepts of (PDP)", and the "Serious Game - Puzzle: Oral Hygiene (PDP)", utilizing a conceptual framework to demonstrate how these games can reinforce skill acquisition through engagement and interactivity. The survey was administered to a population composed of students from the 2023-2024 sixth year dental class (around a hundred students), 31 dentists' students) responded to the questionnaire. Thus, a quarter of the promotion showed a positive interest in participating in this survey. Data were collected through a questionnaire aimed at assessing the experience, ease

of use, relevance of content, engagement, and educational usefulness. The results show that the "Serious Games" are well-received, with high ratings for ease of use (4.4) and content relevance (4.6), as well as an overall experience score of 4 out of 5. While the results are mostly positive, improvements are necessary to maximize educational impact, and student suggestions, such as adding more complex clinical cases, will be taken into account to guide future enhancements within the faculty. The observed standard deviations indicate that, overall, the responses to the questionnaires are consistent and reflect a shared experience among the students, particularly regarding the educational usefulness of the "Serious Games." Moderate variations in certain dimensions, such as content relevance and engagement, highlight specific aspects that could benefit from improvements. In summary, the quality of the responses collected allows us to affirm that the results are reliable and representative of the actual perceptions of the students, thus providing a solid foundation for evaluating the effectiveness of "Serious Games" in dental education.

Figure 6: Results of analysis of questionnaire responses.

Conclusion

The integration of "Serious Games" into dental education offers significant advantages for enhancing training and clinical practice. These interactive tools promote dynamic learning and prepare students for real clinical situations. While previous research shows their potential to improve engagement and knowledge retention, few studies have focused on their application in dentistry, highlighting the necessity of this research. The results of the satisfaction survey conducted among sixth-year students reveal a predominantly positive appreciation for the "Serious Games", particularly in terms of ease of use and content relevance. However, improve-

ments are needed, such as the addition of more complex clinical cases, better integration with the academic curriculum, and the development of a platform that combines several games. Students also suggested using the games regularly to reinforce learning and engagement. In summary, "Serious Games" are deemed useful and engaging, but adjustments are necessary to maximize their educational impact and meet the needs of dental students.

Bibliography

1. Yasmine Kasbi. "Les Serious Games : Une Révolution". *Edipro* (2012).

2. Alvarez J. "Apprendre avec les 'serious games' ? Future scope". *Canope Editions* (2016).

3. Clark C Abt. "Serious Games". (1970).

4. Alvarez J D Djaouti. "Serious an Introduction". 2eme edition, @ edition Question Théoriques (2012).

5. Alvarez Jessel et Djaouti. "Classifying Serious Games: the G/P/S model". (2011).

6. KID. "Pepsiman (PlayStation), Scene: Credits". (1999).

7. D Kletenik., *et al*. "A Serious Game to Teach Computing Concepts". HCI International 2017 – Posters Extended Abstracts (2017): 146-153.

8. P Cohard. "l'apprentissage dans les serious games : proposition d'une typologie". @*GRH* 16 (2015): 11-44.

9. Collock. "le guide pour réussir la gamification au sein de votre entreprise". *Livres Blancs* (2020).

10. Damien Djouti. "Serious Games pour l'éducation : utiliser, créer, faire créer?". *Tréma* (2016): 51-64.

11. Kawin Sipiyaruk., *et al*. "A rapid review of serious games: From healthcare education to dental education". *European Journal of dental Education* (2018): 243-257.

12. Hannig A., *et al*. "Computer supported interactive motion-and game-based training in mixing alginate in dental education". *Journal of Educational Computing Research* 48.3 (2013): 315-343.

13. Ahmed Adam KADA. "Serious Game en Dentisterie". Thèse Doctorat en Médecine Dentaire «Nominé au Prix de 2024 », Faculté de Médecine Dentaire Rabat , Université Mohammed V-Rabat (2024).

14. ProtegerAlerterSecourir.fr. "Jeu de mémoire en formation". (2023).

15. F Benfdil. "Cours PAP – 3eme année médecine dentaire". Faculté de médecine dentaire de Rabat, Université Med V (2022).

16. RéPias. "Le jeu sérieux sur les précautions standard". (2022).