

Anatomix+ Osteoblast

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Abstract. Serious games have become an essential educational tool for teaching human anatomy by fostering active learning and improving knowledge retention. Traditional methods often rely on rote memorization, making it challenging for students to engage with complex anatomical structures. Anatomix+ Osteoblast is a board game designed to enhance students' understanding of the skeletal system through an interactive and gamified experience. By incorporating playful elements into the learning process, this game encourages students to identify bones, recall their functions, and apply anatomical knowledge in a dynamic way.

This article explores previous studies on similar serious games, emphasizing their effectiveness in medical and scientific education. It also discusses the benefits of gamification in learning, such as increased motivation, higher engagement levels, and improved information retention. Additionally, a detailed analysis of the design and implementation of Anatomix+ Osteoblast is presented, showcasing how this game contributes to an immersive and practical educational experience. Future applications, including digital integration and the expansion of the game to other anatomical systems, are also considered. By leveraging serious games, Anatomix+ Osteoblast aims to transform the traditional approach to anatomy education, making learning both effective and enjoyable.

Keywords: Board game, anatomy, bones, education, playful learning.

I. INTRODUCTION

In today's world, knowledge evolves at an accelerated pace, and the skills required for professional success are becoming increasingly complex and diverse. Traditional educational methodologies face the challenge of motivating students while providing the necessary and effective tools for various work environments. In this context, serious games have emerged as an innovative solution that combines entertainment and learning, promoting an active

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educational experience that transcends mere transmission and memorization of theoretical knowledge.

By incorporating game elements into university learning, especially in technical and scientific disciplines, serious games manage to capture students' interest, increase their motivation, and transform the classroom into a simulation laboratory where professional skills can be practiced and perfected in a safe and enjoyable environment. This article presents "Anatomix+ Osteoblast," a board game specifically designed to support the learning of human anatomy, focusing on the skeletal system and offering a playful experience that facilitates comprehension and knowledge retention in the healthcare field.

1 Related studies

Games related to Anatomix+ Osteoblast include:

1. Scientific Publishing Anatomy Flash Cards: This is a series of 335 illustrated flashcards featuring essential concepts of human anatomy and physiology [1].
2. Barron's Anatomy Flash Cards: Each card represents a part of the human body labeled with its medical name, location in the body, and function. There are 265 cards that display muscles, bones, and organs, and they are color-coded according to their general function in the human body [2].
3. Bodymagnet: Learn anatomy while sticking and unsticking 76 magnetic pieces. You will get to know the skeleton, organs, muscles, and various parts of the human body [3].
4. Squishy Human Body: This set includes a transparent plastic model of the human body with 9 soft organs, 12 bones, and plastic muscles, along with forceps, tweezers, an organizer mat for body parts, and a 24-page illustrated anatomy book [4].
5. Anatomy Lab: This kit features 3D DNA molecules, organs, a skeleton to assemble, a skeleton stand, a set of cards (to study the organs and systems of the human body), and a puzzle, along with a comprehensive illustrated manual [5].

The University of Zaragoza, located in Spain, has conducted various studies on games to motivate the teaching of human anatomy. In one of their studies, they implemented the Kahoot platform to assess the knowledge of 84 students during the years 2019-2020. The results showed that most students had not used gamification tools and suggested their use in other subjects. Additionally, the vast majority of students who participated in this activity expressed that Kahoot improved the teaching-learning process and their motivation [6].

1.1 Serious Game in Education

Serious games have been implemented in education with the aim of contributing to the training of students. It has been demonstrated that they improve academic performance and student motivation [7].

Serious games are defined as interactive applications designed to educate, train, or raise awareness among players. They combine playful elements with educational objectives, enabling users to acquire knowledge and skills through immersive experiences and simulations of the real world. Serious games are used in fields such as education, health, and professional training, promoting active and effective learning [8].

Serious games are applied in teaching across various areas and offer benefits such as [9]:

- Active learning: Enhances retention.
- Simulates real situations: Allows students (players) to experience and practice skills in a safe environment.
- Development of social skills: Improves interpersonal and communication skills.
- Awareness and sensitization: Promotes critical reflection.
- Dynamic assessment: Enables real-time evaluation of student progress.

1.2 Success Cases in Medical and Biomedical Education

CLINIX+

The advancement of knowledge and the increasing complexity of the skills required in the healthcare field demand new pedagogical strategies that transcend traditional teaching methods. In this context, CLINIX+, a serious game developed at the University of Guadalajara, has emerged as a success story in medical and biomedical education, transforming the way students acquire and apply knowledge in clinical engineering.

This innovative board game allows students to take on the role of hospital managers, facing real challenges in the administration of medical resources, compliance with regulations, and strategic decision-making. By integrating the regulations of the Mexican healthcare system, CLINIX+ achieves meaningful learning, where participants experience firsthand the challenges of professional practice.

Preliminary results have been extraordinary. Over 300 biomedical engineering students have participated in trials of the game, reporting an increase in motivation and a better understanding of key concepts in hospital management and the use of

medical devices. Additionally, CLINIX+ has been recognized at academic events such as LUDICON 2024, where it won first place in the Best Board Game Design category, solidifying its status as a high-impact educational tool.

The success of CLINIX+ lies not only in its ability to improve knowledge retention but also in the development of soft skills such as teamwork, communication, and decision-making under pressure. Its implementation in various universities and its upcoming presentation at the National Congress of Biomedical Engineering (CNIB 2024) reinforce its value as a model of innovation in higher education.

With plans for a future digital adaptation and a potential expansion to international standards, CLINIX+ positions itself as a benchmark in the teaching of clinical engineering, demonstrating that learning can be interactive, effective, and highly motivating [10].



Fig. 1. Biomedical engineering students playing CLINIX+. It represents the cooperative work and active learning of the students.

1.3 Teaching Anatomy and Its Challenges

Teaching anatomy poses a challenge for educators, primarily concerning the effectiveness of learning. One of the main challenges is the lack of necessary resources, such as anatomical models and visualization technology, which complicates the understanding of human structure. Additionally, traditional teaching methods, which are primarily based on memorization, become insufficient for effectively engaging students [11].

Knowledge of anatomy is fundamental in various disciplines, such as medicine, physical education, and physiotherapy. Understanding this subject enables comprehension of the relationship between the structures and functions of the human body. Furthermore, this knowledge is essential for clinical practice, physical performance assessment, and rehabilitation [12].

Returning to the topic of traditional teaching methods, the fundamental methods in the training of healthcare professionals are [13]:

- Lectures: Presenting slides, models, and projecting images of anatomy.
- Dissection (currently not practiced).
- Anatomical models: Three-dimensional models of organs and systems of the human body.
- Anatomical atlases: Books containing detailed illustrations of human anatomy.
- Laboratory practices: Use of histological preparations and imaging studies (X-rays, CT scans, and MRIs).
- Practical exams: Identification of structures in cadavers or models.

1.4 Gamification and Active Learning

Gamification is an approach that uses elements and principles of game design in non-gaming contexts, such as education, marketing, and health, among others. The goal is to apply game mechanics to make activities that are commonly considered boring more engaging and motivating [14].

Gamification differs from serious games in that gamification focuses on implementing game elements into non-gaming activities to increase motivation and engagement, while serious games are gameplay experiences designed to educate or inform players about a specific topic.

The game design principles applied in education include interactivity, immediate feedback, and presenting challenges that are appropriate to the students' skills. Additionally, using engaging narratives and rewards such as points and badges helps motivate students, while collaboration and competition enhance the learning experience. By integrating these elements, educators transform learning into a motivating and effective process that promotes knowledge retention [15].

Motivation and knowledge retention through play are based on various factors, such as points and rewards that encourage active participation from students, increasing their interest and commitment. Furthermore, play provides a safe environment for practicing and experimenting without the fear of failure, facilitating the consolidation

of knowledge. Immediate feedback allows for real-time adjustments, while narrative and context make learning more meaningful [16].

2 Design of Anatomix+Osteoblast

Objective of the Game

The objective of the game is for players, divided into teams, to work together to identify parts of the human skeletal system, using clues and strategy to avoid the "pathological" words established by the opposing team and advance on the board.

Game Components:

- 53 bone cards
- 15 challenge cards
- 5 skeleton tokens in different colors
- 1 game board

Game Setup:

1. Divide players into teams of two or more.
2. Each team selects a representative to draw a card with the anatomical part.
3. Separate the body cards by regions: skull, spine, rib cage, upper limbs, and lower limbs. Once the cards are separated by regions, shuffle the cards by region and place them in the corresponding regions on the board, which is also divided into 5 regions.
4. There are challenge cards that will be placed outside the board but will also be shuffled; these will be used when a team lands on a space that indicates a challenge.
5. One member from each team will roll a die to determine who goes first; the team that rolls the highest number will go first, and so on until the team that rolls the lowest number.
6. Each team will choose a skeleton token of their preferred color and place it at the starting point on the board.

Game Development:

1. The representative of the team will roll the dice and has two options: land on a space that indicates which region they must draw a card from or land on a challenge card where they will answer questions about the human skeleton.
2. Before starting to give clues, each team writes down two "pathological" words related to the anatomical part.
3. The representative must give clues to their teammates to guess the anatomical part, using only words (not phrases) and avoiding the "pathological" words established by the opposing team.
4. The representative cannot give another clue until one of their teammates says an incorrect anatomical part or the word "pass."
5. Teammates try to guess the anatomical part based on the clues provided, with a maximum of 5 attempts per turn.
6. If the team correctly guesses the anatomical part before time runs out (2 minutes), they roll the dice again to advance on the board.
7. If time runs out or they give incorrect answers, they do not advance, and the next team takes their turn.

Winner of the Game:

1. The team that first reaches 50 points is the winner.

How the Game Cards Will Look:

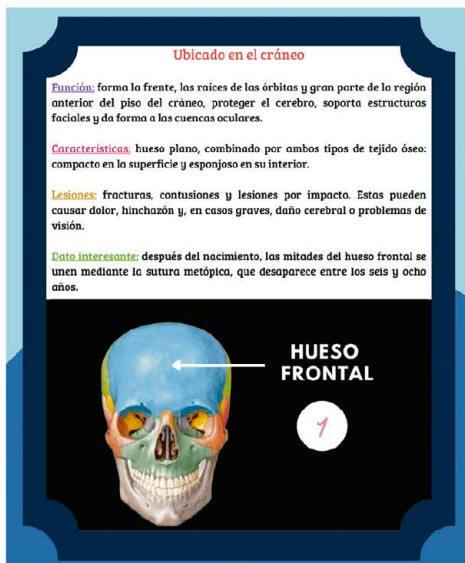


Fig. 2. Game components of Anatomix+Osteoblast. The image shows a card that will be used to develop the dynamics of the game. This card is designed for players to learn about the location, function, injuries, and characteristics of the bone it indicates.

3 Evaluation of the game in learning

The areas of learning that this game can impact include:

- Medicine
- Nursing
- Physiotherapy
- Physical Education
- Occupational Therapy
- Biology
- Health Sciences Education
- Public Health Education

3.1 Method of Effectiveness Evaluation

The methods that will be used to evaluate the effectiveness of the game are:

Evaluation Method	Objective	Tools	Data Type	Application in the Game
User Experience Analysis	Evaluate player satisfaction, enjoyment, and perception	Post-game surveys, interviews, focus groups	Qualitative & Quantitative	Opinions on game dynamics, rules, and mechanics
Usability Testing	Identify difficulties in interface and mechanics	Observation during gameplay, error logs	Qualitative	Difficulty understanding rules, board, and cards
Learning Measurement	Assess knowledge gained about the skeletal system	Pre- and post-tests	Quantitative	Compare knowledge before and after the game
Motivation Assessment	Analyze player interest and engagement	Motivation questionnaires, behavioral analysis	Quantitative	Participation time, enthusiasm level

Performance Data Analysis	Measure player performance and progress	Score tracking, board progress	Quantitative	Analysis of scores, correct and incorrect answers by team
Case Studies & Systematic Reviews	Identify patterns in learning and gameplay	Literature review, game session observations	Qualitative & Quantitative	Evaluation of strategies used by teams
Method Triangulation	Obtain a comprehensive evaluation of effectiveness	Combination of previous methods	Qualitative & Quantitative	Cross-validation of obtained results

Table 1: Methods for Effectively Evaluating Game Function. This table presents a summary of how the game evaluation will be conducted and what tools will be implemented to make this possible, as well as how the results will be presented and what they will be based on.

The variables that will be measured are:

- Information retention
- Engagement
- Test performance

These variables can be measured using the methods outlined above to evaluate the effectiveness of the game.

II. CONCLUSION

Serious games like Anatomix+ Osteoblast demonstrate a promising approach to teaching complex subjects such as human anatomy. By leveraging gamification principles, this board game provides an engaging, interactive, and effective learning experience that improves retention, motivation, and understanding of the skeletal system. Future developments, including digital expansion and the incorporation of new anatomical systems, will further enhance its educational potential.

4 Future applications and project development

This game, designed to identify the human skeletal system, has the potential to expand and evolve in various directions. Some of the future applications and developments of the project include:

- **Expansion to Other Anatomical Systems:** Versions of the game that address other systems of the human body, such as the muscular, circulatory, and nervous systems, among others.
- **Digital Integration:** Creation of a mobile app or online platform that complements the physical game; this could include interactive images, explanatory videos, and quizzes. An online scoring system could also be added, allowing players to compete with other teams globally.
- **Augmented Reality (AR) and Virtual Reality (VR):** Players could interact with three-dimensional models of the skeletal system.

This game can be applied in biomedical engineering educational programs at institutions like CUCEI, specifically in the subject of mechanical anatomy, promoting active and collaborative learning.

The next steps in the research and testing of the game are:

- Testing will be conducted in educational environments to evaluate the effectiveness of the game in learning anatomy. Data will be collected on student participation, information retention, and overall satisfaction with the gaming experience.
- Feedback will be sought from educators and students to make adjustments and improvements to the game design, ensuring that it meets the established educational objectives.

References

- [1] Scientific, "Anatomy & Physiology Flash Cards," Books-A-Million. [Online]. Available: <https://www.booksamillion.com/p/Anatomy-Physiology-Flash-Cards/Scientific/9781932922974>.
- [2] K. H. Albertine, "Barron's Anatomy Flash Cards, 2nd Edition," AbeBooks. [Online]. Available: <https://www.abebooks.com/9780764161599/Barrons-Anatomy-Flash-Cards-2nd-0764>

161598/plp?msockid=2d078e39dc2d6e5325a09ad0dd4e6f85. [Accessed: Feb. 11, 2025].

[3] "Anatomy Game: Bodymagnet," La Chata Merengüela. [Online]. Available: <https://lachatamerenguela.com/products/juego-de-anatomia-bodymagnet>. [Accessed: Feb. 11, 2025].

[4] "Squishy Human Body," GOGIKS. [Online]. Available: <https://www.gogiks.com/producto/squishy-human-body/>. [Accessed: Feb. 11, 2025].

[5] "Anatomy Lab," Grupo Educar. [Online]. Available: <https://www.grupoeducar.com.mx/producto/4953/55485CL/laboratorio-de-anatomia>. [Accessed: Feb. 11, 2025].

[6] A. García-Barrios, A. I. Cisneros-Gimeno, M. J. Luesma-Bartolomé, J. Benito-Rodríguez, E. Barrio-Ollero, and J. Whyte-Orozco, "The Game as a Motivational Factor in Teaching Human Anatomy," *FEM: Journal of the Medical Education Foundation*, vol. 23, no. 6, pp. 347-350, Dec. 2020. [Online]. Available: <https://dx.doi.org/10.33588/fem.236.1097>. [Accessed: Feb. 11, 2025].

[7] "Serious Games: A Strategy to Reduce University Dropout Rates," National Open and Distance University (UNAD), Jun. 21, 2024. [Online]. Available: <https://noticias.unad.edu.co/index.php/2025/6946-los-juegos-serios-una-estrategia-para-reducir-la-desercion-universitaria>. [Accessed: Feb. 11, 2025].

[8] D. Michael and S. Chen, "Serious Games: Games That Educate, Train, and Inform," Thomson Course Technology, 2006.

[9] M. de Freitas and M. Griffiths, "Serious Games and Their Role in Education: A Review of the Literature," *Computers & Education*, vol. 59, no. 2, pp. 1-10, 2012.

[10] V. E. Moreno, R. E. García-Manzo, E. Méndez-Palos, H. Venegas, E. L. Quiroz, and A. Ibarra-Esquivias, "CLINIX+: Serious Game for Clinical Engineering Learning," *CLINIX CITIE 2024 CuValles*, Univ. of Guadalajara, CUCEI, 2024.

[11] A. M. M. A. Al-Azri, A. A. Al-Balushi, A. A. Al-Mandhari, and A. A. Al-Hinai, "Challenges in Teaching Anatomy: A Review," *PubMed Central*, vol. 6461230, 2019. Available: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6461230/>.

[12] J. López and M. García, "The Importance of Anatomy and Its Teaching in the Health Context," *BVS Salud*, vol. 8, no. 2, pp. 30-35, 2019.

[13] J. Smith, *Human Anatomy: An Integrated Approach*, 3rd ed. Madrid, Spain: Medical Publishing, 2020.

- [14] J. García, "The Importance of Gamification in Education," *Journal of Educational Innovation*, vol. 5, no. 2, pp. 45-50, 2022. [Online]. Available: <https://www.revistainnovacion.edu/gamificacion-educativa>. [Accessed: Feb. 14, 2025].
- [15] A. Herranz, "Gamification and Learning: Game Design Principles Applied to Education," *Journal of Educational Innovation*, vol. 10, no.
- [16] K. Hamari, J. Koivisto, and H. Sarsa, "Does Gamification Work?--A Literature Review of Empirical Studies on Gamification," in *2014 47th Hawaii International Conference on System Sciences*, 2014, pp. 3025-3034. [Online]. Available: <https://ieeexplore.ieee.org/document/6758978>. [Accessed: Feb. 14, 2025].