Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 263 (2025) 426–433

Procedia Computer Science

www.elsevier.com/locate/procedia

International Conference on Industry Sciences and Computer Science Innovation

From Paper to Pixels: Teleporting History with TIMECRAX

Júlio Faria[a], João Sousa[a],Rui Lopes[a], Rogério Tavares[a]

[a]*CeDRI, SusTEC, Instituto Politécnico de Bragança, 5300-253 Bragança, Portugal*

Abstract

Abstract: *This study explores the application of game design principles in developing an educational game to teach History through interactive and engaging methods. Upon completion, the game underwent testing by 17 participants. We assessed the outcomes using a survey focused on the effectiveness of games as learning aids. Our findings indicate that creating compelling, entertaining, and educational games demands careful planning, a thorough grasp of game design concepts, and proficiency in multiple facets of game development.*

Keywords: Learning based on digital games; DGBL, Games, Education, History.

1. Introduction

Various studies have demonstrated that students prefer learning using games over other forms of multimedia [1–3]. The challenges of competing for a goal and the feedback they receive from competing or cooperating with each other motivate students to use games with appropriate difficulty levels [4–6]. By immersing in the fun and tension, they improve their self-efficacy, thus becoming motivated to continue playing [7].

Learning through games is an active process, and educational games have proven to be an effective learning mechanism for improving knowledge and skills and increasing student engagement and motivation [8]. Students tend to have positive perceptions of game-based learning [9, 10], which can lead to better attendance and student engagement in their learning [11]. Card games and board games are increasingly popular forms of educational games, providing an alternative learning environment to the traditional approaches to teaching History [8, 12–14]. Complex content can be simplified in a card game format, motivating and engaging students as they learn and practice through social interaction [15, 16]. An approach known as Digital Game-Based Learning (DGBL) uses games as a means to convey learning material [17]. Through the use of video games and computer games, DGBL aims to create immersive and engaging learning experiences to achieve specific learning outcomes and objectives [18]. However, being a recent topic, this area of educational technology lacks research on how to design game environments that promote knowledge

10.1016/j.procs.2025.07.052

construction and deepen understanding [19]. Furthermore, there is the challenge of creating educational games that match curricular topics, which are seen as serious pedagogical tools rather than pure entertainment games whose main goal is to entertain the player [20]. In this [21], the authors study the application of pedagogical elements in creating educational games. To this end, they use interactive multimedia history educational games to make learning history less boring and help students memorize historical facts. However, some studies use well-known entertainment industry games to assist teaching during classes. The study used the video game Assassin's Creed in a history class and concluded that the students felt more motivated, stimulated, and committed during the experience.

2. The Game - Objectives and Development

Styled as a board game, TimeCraX Machine is a 3D online multiplayer video game that can be played by up to 4 players, based on previous work [23]. The game aims to provide players with general historical knowledge while simultaneously offering them entertainment and fun.

2.1. Narrative

Four friends stumbled upon the TimeCraX, a time-travel device, while pretending to be explorers in the forest. As they ventured through the dense forest, they unexpectedly found themselves in an unknown location. Navigating through the thick trees proved difficult, but they persisted. Exhausted from the journey, one of the friends tripped and fell into the underbrush. Unaware of their companion's struggle, the others continued forward, focused on overcoming the obstacles and alert to the unsettling sounds surrounding them. When the last friend recovered from the fall, he discovered a peculiar machine lever instead of a branch. Releasing his foot, the machine came to life, spinning gears and intertwining in a mesmerizing dance. Alone and disoriented, he called out for his friends as his world transformed. The trees disappeared, replaced by a river flowing towards a castle that did not exist moments before. The machine suddenly stopped, leaving the four friends trapped in the same place but at different times. One of them held a broken lever, while the other three searched for their missing friend, examining the fractured gear they had in their hands.

2.2. Game Goal

The TimeCraX Machine is a cooperative turn-based game where each player performs sequential actions before passing the turn to the next player. The players' main objective is to accurately place all historical events on the timeline before the structural integrity of the time machine is compromised. There are 15 distinct components in the time machine, and one of them will malfunction randomly if an event is incorrectly associated with the timeline at the end of each round. Players are defeated if a malfunctioning component fails again, leading to the catastrophic collapse of the time machine. Each player has the option to select and perform one of four possible actions during their turn:

- Acquire a Repair Card (Add a Repair Card to their hand);
- Travel in time (Buy an Event Card and place it on the Timeline);
- Empower the team (Give one of their Repair Cards to another player);
- Repair a malfunctioning time machine component (Use Repair Cards to fix a Component).

2.3. Cards

In this game version, there are two types of cards: Repair Cards and Event Cards (Fig. 1). Repair Cards are used to repair a malfunctioning component of the time machine. Repair Cards equal the number of players required to repair each component. In other words, if three players are in the game, 3 Repair Cards are needed to repair a single time machine component. Players can provide a Repair Card to another player when possessing at least one Repair Card. Each player can hold a maximum of 5 Repair Cards. The Event Card displays the name and an illustration of a worldwide historical event, and the player must examine the Timeline and correctly associate the Event Card with its proper place. If the player is correct, the Event Card remains on the Timeline. If the player is incorrect, the Event Card

returns to the event deck and one of the time machine components malfunctions. The Event Deck shuffles whenever an Event Card returns to the deck and consists of 7 historical Event Cards.

Fig. 1 - Repair Card (left), Event Card (right).

2.4. Timeline

The Timeline (Fig. 2) is a panel that presents a temporal line with 7 slots, each corresponding to a year.

Fig. 2 - Timeline Panel.

2.5. Time Machine

The Time Machine (Fig. 3) consists of 15 components that, collectively, make the machine work. If a component is selected to malfunction when it is already in a malfunctioning state, it cannot be repaired, and the time machine will collapse.

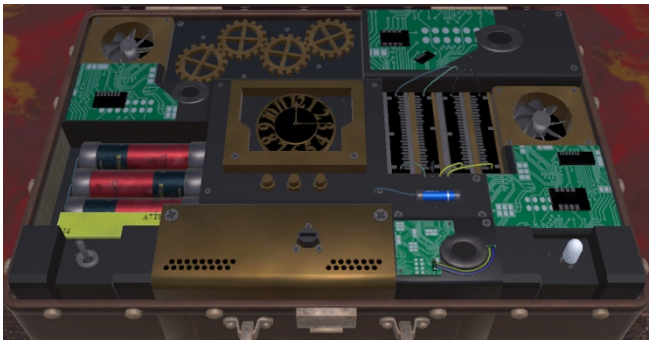

Fig. 3 - Time Machine.

2.6. Level Design

The game becomes more challenging over time. With each new component of the time machine beginning to malfunction, the probability of a malfunctioning component being selected again increases, making the chances of the time machine collapsing even greater. Players must wisely choose their actions to collectively manage risks while trying to complete the Timeline correctly with historical events. Players with greater knowledge of historical events run a lower risk of making mistakes when placing an event on the Timeline.

2.7. Game Design

The entire game was built in a single scene but is visually structured in three parts: Menu (Fig. 4), Lobby Screen, and Game Screen.

Fig. 4 - Game Menu.

Upon starting the game, the player is presented with the Menu, which includes a selection of 5 options:

- Enter your name: A text field for entering the player's name.
- Tutorial: Shows how to play the game.
- Select the number of players: You can choose between 1 and 4 players.
- Exit the game: Exits the program.
- Start game: Takes you to the lobby screen.

The lobby screen (Fig. 5) is a place where you can wait until all players are ready to start the game. In the lobby screen, you can see how many players are in the room, their names, and a log that shows who has entered and left the room. When the room is full, the room creator (the first to enter) can start the game by clicking the "Start" button, which will take all players to the game screen.

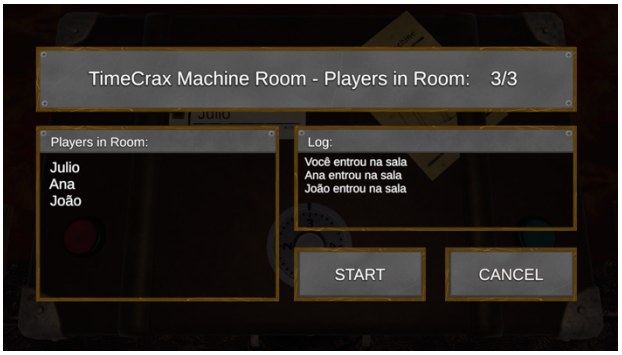

Fig. 5 - Lobby Screen

On the Game Screen (Fig. 6), players can see all the game elements: the Repair Card Deck, the Event Card Deck, the Timeline, the Time Machine, and the HUD. The HUD consists of the Exit Game button, the End Turn button, and various identification plates for each of the players. On each identification plate, players can also see an icon for the Repair Card and a corresponding number indicating the amount of Repair Cards the player has.

Fig. 6 - Game Screen and Round Information

Players can see a notification in the middle of the screen indicating the round number whenever a new round starts. The same happens with each turn; when a player's turn starts, a text appears in the mid of the screen indicating the name of the player who is taking their turn. When a faulty component is drawn again, causing the time machine to collapse, a "Lost in time!" message indicates that the players have failed and that the game has ended. When the last historical Event Card is correctly placed on the Timeline, a message saying, "You're back!" indicates that the players successfully completed the game.

2.8. Development

The development of online 3D games involves a complex and multidisciplinary process that goes beyond programming, requiring the collaboration of various disciplines. As the demand for immersive experiences increases, developers face challenges that go beyond coding, needing a cohesive effort of artists, programmers, designers, and other specialists. The creation of such games becomes particularly challenging for individual creators. After investigation, the Photon PUN framework, combined with the Unity 3D game engine, was chosen for online multiplayer connectivity tests. After exporting models from Blender and textures from Gimp to Unity, the programming phase began, structuring the game into a turn-based system. The coding included several individual scripts, with the GameManager script playing a key role in initializing the game and triggering other scripts in sequence. The game functioned exclusively on the host, transmitting information and changes in real-time to other players. Object animations were generated in Unity as scripts for each object were developed. Extensive testing followed to ensure exact functionality, resolve identified errors, and refine animations, textures, and mechanics.

3. Experiences and Results

A questionnaire was designed consisting of unbiased questions to gather information from the players. Players were asked to play the game once and then respond to the questionnaire. The underlying goal of this exercise was to analyze the players' experiences, understand their perspectives and evaluations of the game, and collect relevant data to improve the game's overall quality in terms of its entertainment value, visual appeal, and educational effectiveness. These data can be crucial for the creators to adjust the game based on player feedback and enhance the game's impact as an effective educational tool. The questionnaire consists of 13 questions:

- Question 01: Is history (in general) a topic that interests you? Answers: YES or NO
- Question 02: Were you able to complete the game to the end? Answers: YES or NO
- Question 03: Were you able to win at least once? Answers: YES or NO

- Question 04: Did you play more than once? Answers: YES or NO
- Question 05: Is the game intuitive? Answers: YES or NO
- Question 06: Do you find the visual aspect of the game appealing? Answers: YES or NO
- Question 07: Do you find the game theme appealing? Answers: YES or NO
- Question 08: Would you recommend this game to someone? Answers: YES or NO
- Question 09: Did you have fun playing? Answers: YES or NO
- Question 10: If the game had gameplay that delved deeper into historical events, would you find it more interesting? Answers: YES or NO
- Question 11: In your opinion, do games like this facilitate students' learning of history? Answers: YES or NO
- Question 12: In your opinion, what is the level of complexity of the game? Answers: VERY EASY or EASY or MEDIUM or DIFFICULT or VERY DIFFICULT
- Question 13: Check which historical events from the game you are not familiar with. Answers: Discovery of Brazil. Battle of São Mamede. Treaty of Tordesillas and Battle of Aljubarrota. Black Death. Fall of Constantinople. Thirty Years' War.

3.1. Results

The experimental group consisted of 17 random participants, aged between 20 and 36 years old, with diverse gaming preferences and skills. No specific instructions were provided regarding the rules, theme, or mechanics of the game. Each participant was asked to engage in the game at least once, with the flexibility to do so individually or in an online multiplayer environment. Table 1 shows the results of the first 11 questions with "Yes" or "No" answers, which comprised the first part of the questionnaire.

Table 1 - First 11 questions and answers (yes/no).

Questions	Yes	No
Question 1: Is history (in general) a subject that interests you?	94.1%	5.9%
Question 2: Were you able to complete the game?	35.3%	64.7%
Question 3: Did you manage to win at least once?	29.4%	70.6%
Question 4: Have you played more than once?	100%	0%
Question 5: Is the game intuitive?	94.1%	5.9%
Question 6: Do you find the visual aspect of the game attractive?	100%	0%
Question 7: Do you find the theme of the game attractive?	94.1%	5.9%
Question 8: Would you recommend this game to anyone?	94.1%	5.9%
Question 9: Did you have fun playing?	94.1%	5.9%
Question 10: If the game had gameplay that delved deeper into historical events, would you find it more interesting?	94.1%	5.9%
Question 11: In your opinion, do games like this make it easier for students to learn history?	100%	0%

Fig. 7 shows the results of question 12 on the player's perception of the game's complexity in a circular graph.

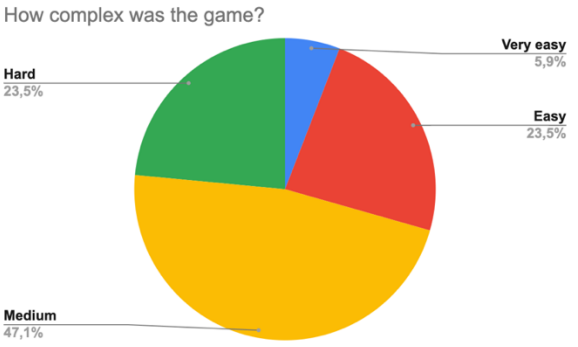

Fig. 7. Answers to question 12.

The bar graph in Fig. 8 shows the results to question 13 on knowledge of some general historical events.

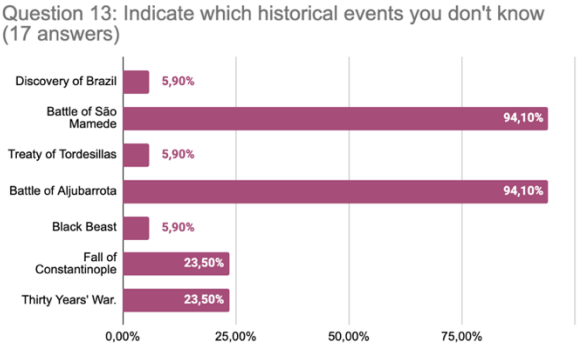

Fig. 8. Answers to question 13.

4. Discussion and Final Remarks

The positive reception of TimeCraX during initial testing indicates its potential as an effective educational tool for historical instruction. The game's engaging mechanics and historically-based scenarios were well-received by participants, who reported both enjoyment and educational value. These findings suggest that TimeCraX may be a valuable supplementary resource in educational settings, facilitating a more interactive and engaging approach to history education. Post-experiential interviews conducted to assess player reflections revealed opportunities for enhancement. Specifically, some participants noted that game instructions could be more explicit and that the pacing could be moderated in certain instances. These observations will inform future game iterations, potentially improving its pedagogical efficacy and overall user experience. However, it is important to acknowledge the limitations of this preliminary study. To address these constraints and enhance the robustness of our findings, we propose the following for future research: conduct a more comprehensive study incorporating diverse age groups of students; align game content with official curricular standards and specific educational objectives across various academic levels; implement controlled experimental studies involving both test and control groups within authentic classroom environments. Implementing these measures will facilitate a more thorough and rigorous evaluation of TimeCraX's educational impact and potential for integration into formal learning environments.

Based on the positive reactions from the game test, TimeCraX shows the potential to be an effective educational tool for teaching history. The engaging gameplay and interesting historical scenarios were well-received by players, who found the game fun and educational. This suggests that TimeCraX could be a valuable addition to the classroom, helping students learn history in a more engaging and interactive way.

Acknowledgments

This work was supported by national funds through FCT/MCTES (PIDDAC): CeDRI, UIDB/05757/2020 (DOI: 10.54499/UIDB/05757/2020) and UIDP/05757/2020 (DOI: 10.54499/UIDP/05757/2020); and SusTEC, LA/P/0007/2020 (DOI: 10.54499/LA/P/0007/2020).

5. References

1. Antal-Berbecaru, A., Larchen Costuchen, A., Dev, S.: Survey Gamification: Engaging Generation Z. Comput. Sch. (2023). https://doi.org/10.1080/07380569.2023.2271486.
2. Archambault, D., Olivier, D.: How to make games for visually impaired children. In: Proceedings of the 2005 ACM SIGCHI International Conference on Advances in computer entertainment technology. pp. 450–453. Association for Computing Machinery, New York, NY, USA (2005). https://doi.org/10.1145/1178477.1178578.
3. García, I.M.: Teaching education in values through games in primary education. In: Global Perspectives on Value Education in Primary School. pp. 120–140 (2023). https://doi.org/10.4018/978-1-6684-9295-6.ch007.
Antal-Berbecaru, A., Larchen Costuchen, A., Dev, S.: Survey Gamification: Engaging Generation Z. Comput. Sch. (2023). https://doi.org/10.1080/07380569.2023.2271486.
2. Archambault, D., Olivier, D.: How to make games for visually impaired children. In: Proceedings of the 2005 ACM SIGCHI International Conference on Advances in computer entertainment technology. pp. 450–453. Association for Computing Machinery, New York, NY, USA (2005). https://doi.org/10.1145/1178477.1178578.
3. García, I.M.: Teaching education in values through games in primary education. In: Global Perspectives on Value Education in Primary School. pp. 120–140 (2023). https://doi.org/10.4018/978-1-6684-9295-6.ch007.
4. Boyle, E., Connolly, T.M., Hainey, T.: The role of psychology in understanding the impact of computer games. Entertain. Comput. 2, 69–74 (2011). https://doi.org/10.1016/j.entcom.2010.12.002.
5. Mayer, R.E.: What Should Be the Role of Computer Games in Education? Policy Insights Behav. Brain Sci. 3, 20–26 (2016). https://doi.org/10.1177/2372732215621311.
6. Mortara, M., Catalano, C.E., Bellotti, F., Fiucci, G., Houry-Panchetti, M., Petridis, P.: Learning cultural heritage by serious games. J. Cult. Herit. 15, 318–325 (2014). https://doi.org/10.1016/j.culher.2013.04.004.
7. Shaheen, A., Ali, S., Fotaris, P.: Assessing the Efficacy of Reflective Game Design: A Design-Based Study in Digital Game-Based Learning. Educ. Sci. 13, 1204 (2023). https://doi.org/10.3390/educsci13121204.
8. Oceja, J., Abián-Cubillo, D., Torres-Trimallez, M.: Games for Teaching and Learning History: A Systematic Literature Review. Presented at the Proceedings of the European Conference on Games-based Learning (2022).
9. Dondio, P.: Does Playing Video Games Give a Child an Advantage in Digital Game-Based Learning? Lect. Notes Comput. Sci. Subser. Lect. Notes Artif. Intell. Lect. Notes Bioinforma. 14475 LNCS, 223–233 (2024). https://doi.org/10.1007/978-3-031-49065-1_22.
10. Konert, J., Wendel, V., Richter, K., Göbel, S.: Collaborative Learning and Game Mastering in Multiplayer Games. In: Serious Games and Virtual Worlds in Education, Professional Development, and Healthcare. pp. 85–104. IGI Global (2013). https://doi.org/10.4018/978-1-4666-3673-6.ch006.
11. Blumberg, F.C., Fisch, S.M.: Introduction: Digital Games as a Context for Cognitive Development, Learning, and Developmental Research. New Dir. Child Adolesc. Dev. 2013, 1–9 (2013). https://doi.org/10.1002/cad.20026.
12. Barba-Martín, R.A., Bores-García, D., Hortigüela-Alcalá, D., González-Calvo, G.: The application of the teaching games for understanding in physical education. Systematic review of the last six years. Int. J. Environ. Res. Public. Health. 17, (2020). https://doi.org/10.3390/ijerph17093330.
13. Hoy, B.: Teaching History With Custom-Built Board Games. Simul. Gaming. 49, 115–133 (2018). https://doi.org/10.1177/1046878118763624.
14. Sanmugam, M., Zaid, N.M., Mohamed, H., Abdullah, Z., Aris, B., Suhadi, S.M.: Gamification as an educational technology tool in engaging and motivating students; An analyses review. Adv. Sci. Lett. 21, 3337–3341 (2015). https://doi.org/10.1166/asl.2015.6489.
15. Arayapisit, T., Pojmonpiti, D., Dansirisomboon, K., Jitverananrangsri, K., Poosontipong, D., Sipiyaruk, K.: An educational board game for learning orofacial spaces: An experimental study comparing collaborative and competitive approaches. Anat. Sci. Educ. 16, 666–676 (2023). https://doi.org/10.1002/ase.2257.
16. Walton-Rivers, J., Williams, P.R., Bartle, R.: Hexboard: A generic game framework for turn-based strategy games. Presented at the 2018 10th Computer Science and Electronic Engineering Conference, CEEC 2018 - Proceedings (2019). https://doi.org/10.1109/CEEC.2018.8674187.
17. Erhel, S., Jamet, E.: Digital game-based learning: Impact of instructions and feedback on motivation and learning effectiveness. Comput. Educ. 67, 156–167 (2013). https://doi.org/10.1016/j.compedu.2013.02.019.
18. Hwang, G.-J., Wu, P.-H.: Advancements and trends in digital game-based learning research: A review of publications in selected journals from 2001 to 2010. Br. J. Educ. Technol. 43, E6–E10 (2012). https://doi.org/10.1111/j.1467-8535.2011.01242.x.
19. Zin, N.A.M., Yue, W.S.: History educational games design. In: 2009 International Conference on Electrical Engineering and Informatics. pp. 269–275 (2009). https://doi.org/10.1109/ICEEI.2009.5254775.
20. Khan, A., Ahmad, F.H., Malik, M.M.: Use of digital game based learning and gamification in secondary school science: The effect on student engagement, learning and gender difference. Educ. Inf. Technol. 22, 2767–2804 (2017). https://doi.org/10.1007/s10639-017-9622-1.
21. Kee, K., Graham, S., Dunae, P., Lutz, J., Large, A., Blondeau, M., Clare, M.: Towards a Theory of Good History Through Gaming. Can. Hist. Rev. 90, 303–326 (2009). https://doi.org/10.3138/chr.90.2.303.
22. Karsenti, T., Parent, S.: Teaching history with the video game Assassin's Creed: effective teaching practices and reported learning. Rev. Sci. Math. ICT Educ. 14, 27–45 (2020). https://doi.org/10.26220/rev.3278.
23. Lopes, R., Tavares, R., Mesquita, C.: TimeCraX: Time-travelling to learn history. In: Conference: SBGames 2015 - XIV Simpósio Brasileiro de Jogos e Entretenimento Digital (2015).