The Royal Game of Ur: A Digital Reproduction of an Ancient Sumerian Game

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Abstract— The game industry is continuing to grow and users can enjoy this kind of products on diverse platforms (e.g., PC, game consoles, smartphones, tablets). While there are many developers working on modern game genres for pure entertainment, it is also interesting to exploit the attractiveness of games for serious purposes. To this aim, we have devised a mobile game able to merge the rediscovery of an ancient board game played by ancient Sumerians with the pleasure to play on mobile devices. The goal of the project is also to raise the interest of fourth graders in history, in particular in Sumerians, through the digital version of a game that was played thousands of years ago. Our game includes the possibility for teachers to add historical trivia shown to the players while using the application.

Keywords— *Mobile app, Serious game, Sumerians, Unity*

I. INTRODUCTION

The mobile video game market is constantly growing and consolidating as a worldwide phenomenon. The mobile gaming market was valued at US$95.448 billion in 2019 and is expected to grow at a CAGR of 23.59 % to reach a market size of US$420.386 billion by 2026 [1]. The continuous growth of this sector is linked also to the popularity of smartphones and to the widespread availability of broadband connectivity. The mobile game market also includes serious games, that can be used for several purposes, such as training, rehabilitation and education [2]-[8]. Indeed, educational mobile games are a great way to teach kids various subjects that could otherwise be boring and difficult to memorize. The use of this technology brings benefits for both students and teachers, allowing students to improve their knowledge of technology and making teaching more fun.

In this context, this work is focused on the creation of an educational game developed while keeping in mind how a teacher could bring it to class to teach children while they play and have fun. Our application digitally reproduces an ancient Sumerian game called *The Royal Game of Ur*, in which, in addition to being able to play the game, information and curiosities about the Sumerians will be displayed to allow students to learn while playing. Being an ancient game, the game's mechanics are very simple to allow players to focus more on playing while having fun and learning, rather than trying to understand even more advanced rules and mechanics of it.

II. RELATED WORK

Serious games have been adopted in several areas of our lives. For instance, PlayWithEyes supports children eyes testing aiming at lowering the drop-out-from-therapy phenomenon [9]. Other works focused on the assessment and rehabilitation of children affected by Cerebral Visual Impairment (CVI) [10] or by dyslexia [11], or even for articular mobility [12].

Serious games have also found application in civic education. For instance, PadovaGoGreen is aimed at teaching people how to recycle waste correctly, acknowledging that sustainability is a key concept in our society and proper waste sorting is limited by citizens' knowledge on the topic [13].

The educational use of serious games is particularly relevant when considering children, teenagers and school subjects, which can differ from what they like to do, receiving little attention and interest. In this context, PizzaAlLancio embodies a serious game to help children understand fractions, in particular, equivalent and complementary ones [14], [15]. The game is based on a delivery boy who happens to eat some slice of pizza while transporting it and the player is asked to determine the fractions of the pizza eaten or left. Instead, Rojas-Salazar *et al.* [16] proposed a game to introduce Binary Search Trees (BST) to computer science college students.

Similar to the present work, as it is based on ancient games, Fox and Geese is the digital version of a game played by ancient Romans to raise children's interest in ancient history [17]. The work presents the developed game but no evaluation of its acceptance or effectiveness.

III. GAME DESCRIPTION

The Royal Game of Ur (Fig. 1) is a two-player strategy race board game that was first played in ancient Mesopotamia during the early third millennium BC. The game eventually evolved into something similar to backgammon. The Royal Game of Ur received its name because it was discovered by the English archaeologist Sir Leonard Woolley during his excavations of the Royal Cemetery at Ur between 1922 and 1934, and the rules of the game have been found written on a Babylonian clay tablet. Based on this tablet and the shape of the gameboard, British Museum curator Irving Finkel reconstructed the basic rules of how the game might have been played.
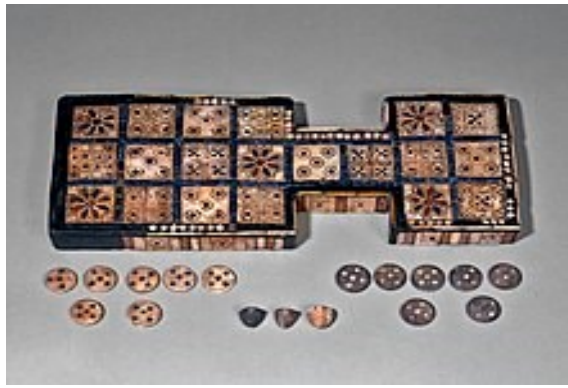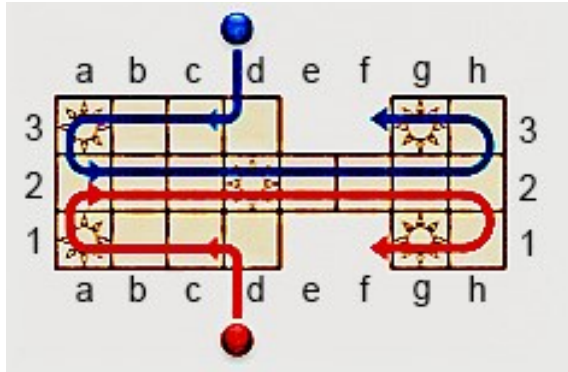
Fig. 1. Ancient board of the Royal Game of Ur.

Fig. 2. Movements on the board.

A. Game Purpose and Rules

The main purpose of the game is to get all your pieces off the board before your opponent, all this requires strategy and even a little luck. In order for a pawn to leave the chessboard, the dices must give the right to an advance in exact number corresponding to the missing squares (if a square is missing, you will win only if it allows the advancement of a square), otherwise if it is not possible to move other squares pawns the turn will be passed.

The rules of the Ur game have never been fully clarified, although some consensus regarding a possible set of rules exists. The game can only be played by two people at a time who compete 1 vs 1. The game is composed by:

- A table of 20 cells.
- 14 pawns of two different colors (7 for each player).
- 3 dices to roll.

Initially the table is empty, and Player 1 goes first. The two players enter the table with their pawns from two different and symmetrical points. Player 1 enters from square **d3** while Player 2 from **d1** (Fig. 2), during the game the pawns of Player 1 run through the squares **d3-c3-b3-a3-a2-b2-c2-d2-e2-f2-g2-h2-h3-g3** while the pawns of Player 2 run through the squares **d1-c1-b1-a1-a2-b2-c2-d2-e2-f2-g2-h2-h1-g1.** Each player has only one move per turn, the move is determined by the roll of three four-sided, tetrahedron-shaped dices. Two of the four corners of each dice are red and the other two are black. The possible results of throwing the 3 dices are:

- 0 red dots (hence 3 black dots) - allows the player four advances with a pawn already on the table and to reroll the dices.

- 1 red dot - the player must necessarily pass the turn.

- 2 red dots - allows the player only one advancement with a pawn already on the table and to reroll the dices.

- 3 red dots - allows the player to either place a new pawn on the table and reroll the dices or to make five advancements with a pawn already on the table and then reroll the dices.

To place a pawn on the table it is therefore necessary to roll a 3 red dots; when you get it, you roll the dices again and on the basis of this throw the pawn moves. Until you get the roll that allows you to put a pawn on the table, the player must pass the turn. When the player gets a score of 6 by rolling the dices and inserts a pawn, if the next roll is rolled 1 red dot, the turn must be passed on, and the pawn is removed from the table. At each turn it is possible to move only one pawn based on the throw made. When a player's pawn lands in one of the squares **a3, g3, d2, a1, g1**, the opponent must pay 2 coins of her/his money as a prize for the winner of the game. While moving, a player's piece can cross squares that are already occupied but cannot complete the movement on a square occupied by one of their own pieces. If they finish their move on a square occupied by an opposing pawn, they send it back off the table. If a player has no moves available, he must pass the turn. The pawns that manage to cross the central squares of the board unscathed can reach the exit of the board. The only way to get a pawn out of the board is to roll the dices with the exact value of the missing squares. The first player to get all her/his pieces off the board wins the game/prize.

B. Easy Mode

The original game had a lot of cases where players progressed very slowly through the game, often only passing the turn to each other while waiting for a lucky dice outcome. Therefore, to make the game more dynamic and appropriate for children, we have also implemented the possibility to play with simplified rules. The rules are similar to the original ones, but with the following changes:

- Each player has only 4 pawns.

- If a player, for 5 turns in a row, fails to move or to enter a pawn, a pawn is automatically inserted into the board.

- There can be help/tips during the game.

IV. APPLICATION REQUIREMENTS

The game is mainly designed to be playable on a mobile platform with an Android operating system, but it has also been tested on a PC with Windows 10 and it resulted fully functional. To play on the mobile platform the following is needed:

- An operating system with Android 4.4 or higher.

- 50 MB of available space.

- The possibility to use the touch screen to perform game actions.

To play it on a PC, only 1 MB of free space is needed.

A. Game Modes

We have implemented 2 game modes:

- **Single player**: The two players play on the same device locally. The board displays the dices to be thrown on the device and the pawns for each player who will have to follow the game turn defined by the application. Through this mode the user can familiarize with the game and learn curiosities about the Sumerians. In this mode you can choose whether to play the easy or original version.

- **Multi-player**: Two devices can connect to let their owners to play remotely against each another. A client-server architecture is employed: the player who creates the room inside the Photon server is the master client while the player who connects to this room is a regular client.

V. Design and Implementation

The game is structured in order to provide a graphic part created thanks to the resources provided by the Unity game engine, while the backend of the application is managed through scripts in C # that always communicate with Unity to perform the actions required for the correct execution of the game. The game structure consists of 3 main scenes each containing a different operating logic, the 3 scenes in which the game is divided are:

- **MainMenu**: the scene that manages the main menu visible when the application starts.

- **Game**: the scene that manages the game between players locally.

- **MultiplayerGame**: the scene that manages the game between remote players.

A. Game Engine

The game engine used to create the application is Unity for its simplicity, capabilities and documentation. Moreover, Unity supports many gaming platforms such as PC, Android, IOS, various consoles and offers an easy game porting for each of these platforms. Unity allows to create three-dimensional (3D) and two-dimensional (2D) games, as well as interactive simulations and other experiences in video making and offers an assets store with useful libraries and / or graphics packages to create the game.

B. Multiplayer Connection

The online multiplayer mode was created using Photon Unity Networking (PUN) which is a Unity package for multiplayer games. Photon has facilitated the implementation of various functions related to the online connection, providing APIs for the creation and management of an online game. The different steps related to managing an online game for the application are illustrated below.

We employed the free version of Photon and its dedicated servers to host the rooms for the players. A maximum of 20 players can be connected simultaneously, which is sufficient to test our application. Once the connection with the master server is obtained, it is possible to enter a lobby or create a new one. In the application, the player who creates the lobby first is the master client, i.e., the one who owns the lobby and who decides when to start the game. When another player searches for a game, she/he is automatically placed in the lobby created by the master client.

Once the game is over, it is possible to exit the game by clicking the **HOME** button; the player can then find a new lobby for a new match. It is possible to exit the game even during the game, by clicking the **HOME** button and disconnecting both players from the game.

C. Firebase Database

To save data concerning curiosities as well as to have a scalable system for future additions, we have used Firebase's Realtime database. Firebase is a platform for creating applications for mobile and web devices developed by Google that allows the integration of various services (including the Realtime database) to manage various functions for your application. The integration of the database into the application and the exchange of data between them is facilitated using the firebase API.

The database saves the data in JSON format and each curiosity is characterized by a unique ID and the following data.

- Date: contains the entry date of the record.

- Language: contains the reference language of the curiosity.

- Text: contains the text of the curiosity.

D. Application Design

When the application starts, the first menu displayed is shown in Fig. 3. It is the main menu showing the main functions that can be accessed and a drop-down menu at the top right of the screen to choose the game language (currently, either English or Italian). The functions offered by the menu are (in order):

- PLAY - allows you to start the game by choosing between two modes (Fig. 4):
  - Local: allows you to play on the same device against another player, offers two modes of your choice (Fig. 5), EASY where the game employs our simplified rules to speed up the game and ORIGINAL where the original rules are used.
  - Multiplayer: allows two players to play remotely by connecting through their devices to the game server (Fig. 6).

- CURIOSITIES: functionality accessible only to the holders of a special password (Fig. 7), e.g., the teachers, allows you to manage the curiosities that are shown to players before the game in LOCAL mode (Fig. 8 and Fig. 9).

- RULES: section containing the purpose and the rules of the game (Fig. 10).
- QUIT: button to exit the application.

Fig. 3.   Main menu.

Fig. 4.   Game mode.

Fig. 5.   Game rules choice in local mode.

Fig. 6.   Multiplayer mode.

Fig. 7.   Enter password screen.

Fig. 8.   Curiosity manager.

Fig. 9.   Add/edit curiosity.
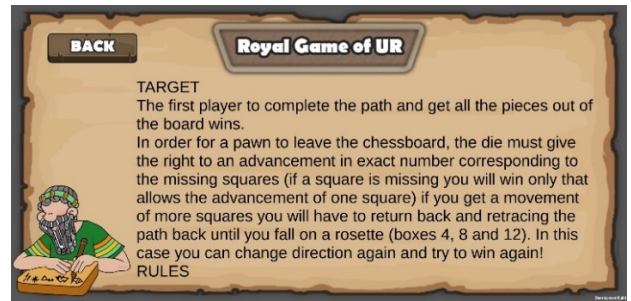
Fig. 10. Rules explanation.
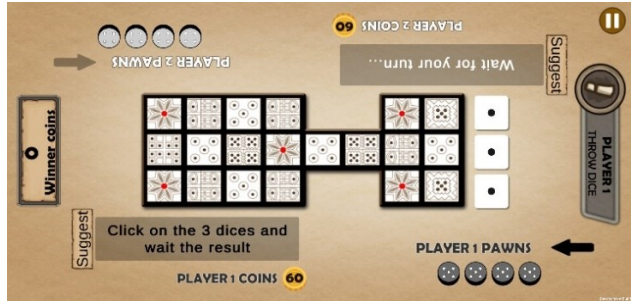

Fig. 11. Example of curiosity display.
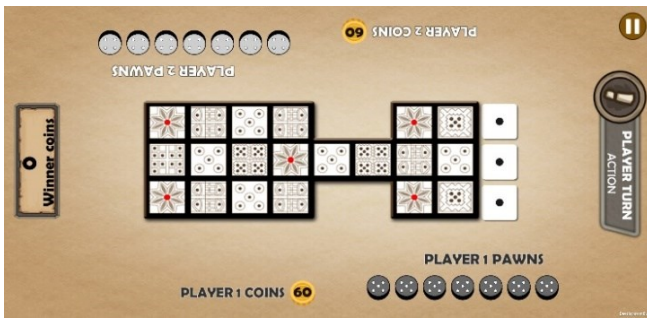

Fig. 12. Easy rules mode.

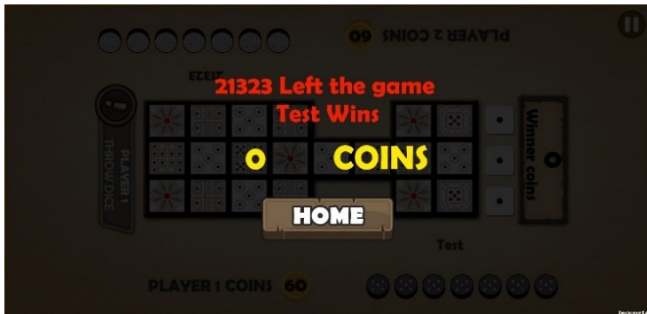Fig. 13. Multiplayer and original rules mode.

Fig. 14. Pause menu.

Fig. 15. Game over screen.

Fig. 16. Game application running on a PC.

In local mode, a random curiosity among those defined in the database is displayed at the beginning of the match (Fig. 11). Depending on the difficulty and the mode chosen, different screens of the game will be displayed, for the local mode. With easy difficulty the screen will be the one shown in Fig. 12, while

for both the multiplayer mode and for the local with original difficulty, the screen will be the one in Fig. 13. While the game is running, it is possible to pause it, by doing so the pause menu (Fig. 14) will be shown where it is possible to return to the home or return to the game. Finally, when the game ends, the screen in Fig. 15 will be displayed, containing the name of the winner, the sum of coins won and the button to return to the home.

The game ends when one of the two players completes the game's purpose described in the rules, or in the case of multiplayer mode, when one of the two players disconnects.

E. Application Deployment

The game is designed to be mainly run-on Android devices, which is why it is released and distributed in APK format. Thereby, the application has been tested on 4 different mobile devices which are: Xiaomi Pocophone F1, VANKYO S10 Tablet, Xiaomi Redmi 9A, Alcatel 1SE. However, the application is also exportable and executable on Windows PC as shown in Fig. 16.

VI. GAME EVALUATION

To assess our game, we have involved 16 fourth graders. All of them had already studied Sumerians for a few weeks as part of their regular school program. They studied when and where Sumerians' civilization proliferated, as well as their main characteristics, innovations and evolution.

We asked to our participants to play in couples with our digital game in the easy rules mode and then we asked them to express their level of satisfaction employing a five-level Likert scale from 1 to 5 (lowest and highest rank, respectively). Results to the question *"Did you like the game?"* are reported in Fig. 17 which shows the five possible ratings on the x-axis and the number of students expressing that evaluation on the y-axis.

As clearly shown by the chart, participants enjoyed the digital version of the game even if the original game was actually intended for adult players. To mitigate this issue, as mentioned, our game offers two possible modes: the original set of rules and a slightly simplified version (with less pawns and with reduced possibility to stall in the game). Still, the rules resulted a bit complex initially for the children to grasp and required a few trial matches. However, this issue was mitigated by the fact that we designed the game to help the player with this by letting her/him know at each step which are the possibilities offered by the dice roll outcome. Indeed, the outcome shown in Fig. 17 demonstrates that the children actually enjoyed playing the game.

To evaluate the efficacy of the game in raise the interest towards ancient history (and Sumerians in particular). We have asked the children *"Would you like to study more about the history and life of Sumerians?"*. This very same question was asked twice to all children: the first time before seeing the game and the second time after having played with the game for about half an hour. Again, we used a five-level Likert scale and we report the two outcomes (pre and post playing) in Fig. 18. As clearly shown in the chart, the interest of children in Sumerians rose significantly and we believe that the outcome could be even better with further improvements on the game such as: enhanced graphic/animation, leaderboard, goals and sub-goals.
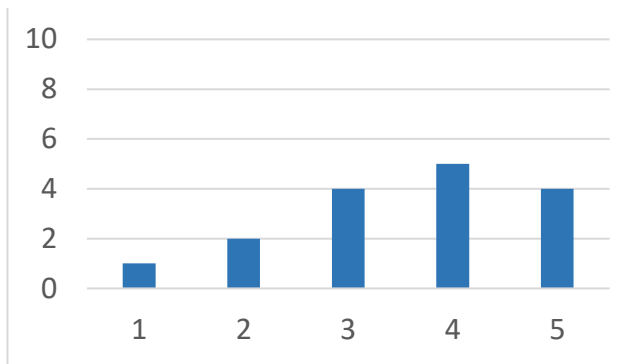
Fig. 17. Game quality assessment; *"Did you like the game?"* five-level Likert outcome (1 lowest grade, 5 highest grade).
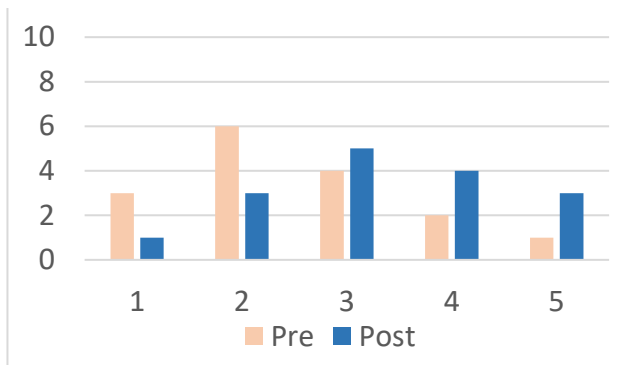

Fig. 18. Game efficacy assessment; *"Would you like to study more about the history and life of Sumerians?"* five-level Likert outcome (1 lowest grade, 5 highest grade)

VII. CONCLUSIONS

Educational games represent a great resource within the world of video games but also in the teaching sector. In this paper the importance of these games was discussed and shown though a representative example. The application that was created represents a proof-of-concept demonstrating how it is possible to create an educational game that can be played locally and online using a dedicated server. The choice of The Royal Game of Ur offers the opportunity to acquire information regarding the game and the society of the Sumerians. Finally, some features have been defined to be implemented in the future to increase the popularity of the game, the inclusion it offers and the opportunities it can offer.

This work can be expanded in several directions. First of all, we would like to further test its efficacy in engaging students in the study of Sumerians. To this aim, we intend to consider more students and at different levels (for instance, Sumerians are studied even in high school) in order to compare results. We would also like to further simplify the current version to be even more tailored for kids in elementary school, possibly utilizing colorful and cartoon like graphics. Finally, we would like to implement the game, including the historical trivia, even in Virtual/Augmented Reality [18], [19].

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