

## APPENDIX A

### Design Principles

The game was designed based on skills matrix proposed for PISA 2015 (OECD, 2017) (Appendix B). Moreover, several design principles were considered to implement the game.

The theoretical framework proposed by Plass et al. (2015) was chosen. The framework proposes a flexible structure that can be applied to any game-based learning design process. As a tangible example of this, Plass et al. (2015) propose seven dimensions (Table A.1) that the game design must include to achieve a ludic learning experience:

**Table A.1**

*Game characteristics*

Dimension	Game implementation
Content and Skill	<p>The game is not designed to teach a specific curricular content but instead to develop CPS as a skill.</p> <p>The use of roles for each player was prioritized for the design of the collaborative game (Author et al., 2009; Seif El-Nasr et al., 2010).</p> <p>The game considered the condition of a collaborative task previously described in the literature (Author et al., 2011): a common team goal was maintained (Dillenbourg, 1999; Seif El-Nasr et al., 2010); the puzzles were based on positive peer interdependence (Johnson &amp; Johnson, 1999) and coordination and communication between them (Gutwin &amp; Greenberg, 2004); the responsibilities of each player within the team were defined (Slavin, 1996); evidence of the rest of the team's actions was included in order to ensure there was group awareness (Janssen et al., 2007); the reward system, although minimal, was always collective (Axelrod &amp; Hamilton, 1981); and all restrictions, such as health and energy, were shared by the team (Seif El-Nasr et al., 2010).</p>
Incentive system	<p>In this case, rewards are external to the game and given when the user demonstrates the required learning dynamics. Collaboration should therefore be driven by a desire to play, explore and solve the game with peers, rather than a reward that does not contribute towards this goal.</p> <p>The game implements internal incentives so that the difficulty of the task would help motivate users to develop more effective collaborative strategies in order to solve it. In this sense, the game only includes an experience point system, in which players accumulate points as they advance and solve puzzles within the</p>

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	game. However, these points cannot be used for anything inside the game and do not lead to any prizes for the students.
Learning mechanics	The design includes the use of complex scaffolding and soft scaffolding (Chen & Law, 2016), including text messages that seek to guide the students in order to recognize the forms of interaction that are available to them (Feedback). On the other hand, the logic of graceful failure was also incorporated (Juul, 2013), in which any mistake made by a player can easily be amended or, at least, would not be serious enough to make the player give up too soon. In this sense, the health and energy have a long duration and is easy to recharge. The system therefore avoids frustration becoming a barrier to learning, while also not being overly simple and negatively affecting the cognitive learning process (Kiili et al., 2012).
Assessment mechanics	The assessment mechanics within the game are based on the increasingly interdependent interactions that the team must have in order to progress.
Aesthetic design	The game interface. It was designed to emulate standard controls on modern consoles and to allow clear interaction for students. The game was designed so that the three players can interact with each other via oral and kinesthetic speech freely throughout the experience.
Narrative design	The narrative looked for the players to co-create their own story. In this sense, the system does not include a single, particular narrative. Instead, it shows or reveals a series of images, to which the group can then attach a meaning or emotion, based on whatever they co-construct (Maine, 2017).
Musical Score	The music consisted of 6 open source songs from the chiptune album called “Music for an Unmade Forest World” by the artist Visager (2017), taken from the Free Music Archive (2018). Sound effects for the players’ actions were also included.

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The interface is managed by the teacher or operator (Figure A.1) and consists of two sections grouped on the right side of the screen. The first one is to activate the server (start the game), enter the number of players, and the stage at which each game room will start.

Action Panel		
Activate Server		
Copy The Chat In Current Directory		
Max Player In Rooms:	Enter N°...	Send
SceneToLoad Pre - entry:	Enter N°...	Send
Reset Server		
Enter N°...	Enter N°...	Enter N°...
CScene Reset	CScene Reset	CScene Reset
Enter N°...	Enter N°...	Enter N°...
CScene Reset	CScene Reset	CScene Reset
Enter N°...	Enter N°...	Enter N°...
CScene Reset	CScene Reset	CScene Reset

Figure A.1. Interface server control panel

In the second section, there are fifteen boxes. In these, the operator can monitor that the players enter the game correctly. Each of these units can be manipulated by the teacher. The system can: 1) restart the level; 2) Send players to their last checkpoint; and 3) change the players' stage. This section is helpful in case of problems with the game or if teachers want to move a team from one stage to another for a particular reason.