2020

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on **VIDEOGAME SCIENCES** and **ARTS**

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SPC videojogos

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Inês Barbedo, Bárbara Barroso, Beatriz Legerén, Licínio Roque, João Paulo Sousa

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ORGANIZATION

Escola Superior de Comunicação, Administração e Turismo,
Campus do Cruzeiro, Av. 25 de Abril Lote 2
5370-202 Mirandela

Phone: (+351) 278 201 340
Email: videojogos2020@ipb.pt

Sociedade Portuguesa de Ciências dos Videojogos
Instituto de Ciências Sociais
Universidade do Minho
4710-057 Braga - Portugal

http://www.spcvideojogos.org/

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VENUE

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INTRODUCTION

The 12th Edition of the International Conference on Videogame Sciences and Arts, Videojogos2020, is a joint organization of the School of Public Management, Communication and Tourism – Polytechnic Institute of Bragança (EsACT – IPB) and the Portuguese Society of Videogames Sciences (SPCV). This year, due to the pandemic context, activities were conducted online.

The Videojogos2020 conference is at the forefront, looking at the exciting emerging field of games research from an academic and scientific perspective and providing novel directions and theoretical foundations for emerging advances. For several days, it was a space for dialogue and discussion among researchers, professionals, students and interested locals on videogames related topics and their impact on several aspects such as society, health, heritage, economy or education. The recent emergence of an enthusiastic research community focused on game-related applications, driven by the growth and maturation of the video game industry, and its growing recognition by the media and the general public, is prompting the interest of researchers from a wide range of fields: arts, design, social sciences, technology, etc.

We would like to thank all the authors for their contributes, submitted in three conference categories: papers, interactive demos, posters, which enabled to streamline sessions about Communities, Characters, Technology, Media and Industry, Game Based Learning, Accessibility, and Design & Development. And in the workshops, that occurred in the preconference day, authors worked with participants in small groups fostering insights into the tools of the producer - agile methodologies and risk registers, enabling the play, analysis and ideation of news games, and also experiencing how to use free capture data to animate characters.

A special thanks to the keynote speakers for their marvellous presentations. Rui Craveirinha discussed what video games are, why we play them and how we feel as players, sharing his vision as a player and as a researcher of the art of playing. Oscar Garcia Pañella reflected on the situation of confinement we find ourselves in and how to use the power of motivational design and gamification.

The participants were mostly from Portugal, the host country, but with significant participation from Spain – Madrid, Catalonia, Galicia, Basque Country - and also from Brazil, Peru and Mexico, allowing us to conclude for the feasibility of proposing an Iberian organization.

Stay safe!

Inês Barbedo
Bárbara Barroso
Beatriz Legerén
Licínio Roque
João Paulo Sousa

KEYNOTES

RUI CRAVEIRINHA
Rui Craveirinha is Games User Researcher at Player Research, getting all manner of insight on how players play their videogames. He has a PhD in Information Sciences and Technology (specialized in Human--Computer Interaction) and a great passion for videogame design, research and development. His past research covers, mostly, game design studies and development of new tools for video game development.

“The Art of Play”
What are video games? Why do we play them? What makes them feel so special to play? Is it - as everyone so fervently believes - that they’re art? What even is art, anyway?
Legend has it that I was born with a famicom controller… father tells me the cable served as the umbilical cord. It’s thus no surprise that I spent most of my waking life feverishly musing on these deep questions, whether I was criticizing games for IGN or teaching Game Design at the University.
In this talk I will take you on a journey of the personal and the universal, retelling three distinct Histories: the History of (Video) Games, from Chess to The Last of Us Part II; the History of Aesthetics, from Plato to Dickie; and my own personal history, from playing famicom to analysing players experience at Player Research. Together, these stories will intertwine in a way that might just answer all those questions.
My answers can surprise, provoke, and on the rarest of occasions, may even provide true insight. By the end, I hope to have at least convinced you of why video games are a wondrous medium which state of the art theories and tools often downplay in terms of their sheer complexity, novelty… and beauty.

OSCAR GARCÍA PAÑELLA
Oscar García Pañella directs the Videogame Degree at ENTI-UB Barcelona, the online Gamification & Transmedia Storytelling Master Program for the IEB School and co-directs the Serious Games for Health & Sport initiative (ENTI-UB and the Harvard Medical School). In addition to that, Oscar García Pañella works as a senior Gamification consultant for Cookie Box, as a way to bring the fields of Transmedia and Dramanagement to the Human Resources Departments.

“Seeking presence through virtuality – applying gamification to support the memorable experiences we deserve”
We are still confined. Both physically and mentally, one or another or both depending on our specific context. And we are human beings and thus with the need of social interaction, fantasy experimentation, true storytelling and memorable challenges. We people love to explore, socialise, communicate, share, help, achieve... and we need to feel engaged while doing so. Even more if using virtual devices for the majority of our communications. And because we are the users, we should be at the centre of any design. Therefore, is there a science that can help us all to achieve the correct creation of valuable remote and/or hybrid experiences? Can we learn to design in a way that extracts the best opportunities from our current situation by allowing us to keep our networking alive while maintaining rigor and guaranteeing fun (and seriousness)? How can we expect to adapt ourselves to the "new" transmedia means available if not designing from both the experiential and memorable views? Welcome to the playing realms of motivational design and gamification!

WORKSHOPS

Title

The Tools of the Producer – Agile Methodologies and The Risk Register

Authors:

Inês Lagarto (ineslagarto.dev@gmail.com).

Institution / Company

Lab42 Games – Sumo Digital Group

Abstract

On this workshop you will find an introduction to what it means being a produce on a day to day basis and try to cover two of the main tools of the producer: The Agile Methodologies and the Risk Register Game.

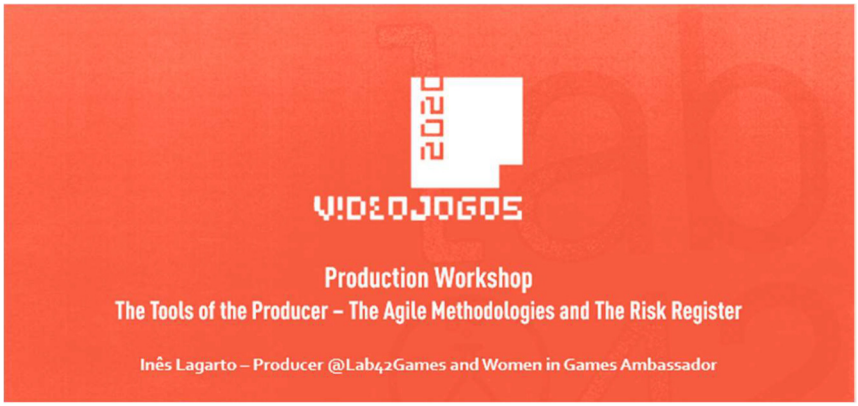
Keywords:
Game Production, Agile Methodologies, Risk Register, Game Development

Technical Requirements

Excel, Pen and Paper

Number of participants

2- 18



Description

Production is an essential role within the game development team. Although at first glance this might seem a hybrid and replaceable position easily covered by any of the team members, rapidly game dev's understand that is not true at all when working in a daily Studio environment.

Planning most of times makes the difference between a released game and another unfinished prototype in one's portfolio. But who wants to do estimates, risks, budget work, talk to clients, make sure the project is within the scheduled Milestone plan and maintain communication flowing between the members of the project?

Let us do a quick run through the high-level roles within a team:

The Coder? Coders should be implementing mechanics, physics, sounds, lights, VFX, etc. are implemented according to the documentation made by the Designers and Artists.

The Artist? Artists should be making our game look as best as they can by creating assets, VFX and luminance to make it shine. The Designer? Designers find solutions to convey aesthetics and feelings into the game world and document everything in the process. Sometimes they even implement these worlds in engine with assets provided.

Should any of these roles making managerial tasks? The answer is no. They should be focusing on making the game work and find solutions to deliver it in time. What they should not be doing is managing, keeping client relationships, or working outside of their striking team. So, if you ask how important the role of the Producer is in the Game Development process to a Studio Manager is the answer will be, critical. Is up to the Producer to communicate the work that is being done within the team, share it across all different teams and make them communicate if needed. But how does a Producer know what is really going to impact the development process of the game, what needs to be communicated and when to clients and or other members without disrupting the flow of the work?

On this workshop we will cover the one of The Tools of the Producer – Agile and Risk Registers. We will cover this topic by:

- Make a stand-up simulation.
- Explain what the Producer's Role is
- Quick intro to tools and Methodologies for Production within game development
- Risk Management & Assessment exposition and exercise using excel
- Role play exercises to cover the Agile Methodologies

By the end of this workshop you will have a broader understanding of what is a Producer, what tools Producers use daily and how to create and assess risks in your game development project.

References

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3. The Project Manager – Guide to use a Risk Register, https://www.projectmanager.com/blog/guide-using-risk-register, last accessed 2020/11/23

Title

Polar Survival.

Authors:

Mikel Carpio (mikelcarpio97@hotmail.com), Pedro Barragán (pedrobp99@hotmail.com), Fernando Jesús Pérez (jesusfernando.perezmartin@gmail.com), Juan Piccoli (jpiccoli000@gmail.com), Laura Schober (laura.schober1993@gmail.com), Sergio Uceda

Institution / Company

Francisco de Vitoria University

Abstract

While playing Polar Survival, you will have to find enough food to survive. Seals are part of the polar bear´s diet you´ll incarnate, but the glacier you are living in is melting as time passes, and those seals will try to escape, furthermore, there are several chances for you to face other polar bears which are hungry as well, and that will turn your survival trip into a really dangerous task.

Sadly, due to human activity in the North Pole, and the global warming situation we are living nowadays, poles are melting faster every minute, reducing polar bear´s habitat and the amount of food they can find, putting them in grave danger.

The truth is that cannibalism between polar bears, is a fact, and it has been growing up over the last years, and our team takes part of its responsibility trying to raise awareness about this situation through this newsgame.

As we have already explained, the player will have to find food in the glacier. This glacier will melt over the time, so the habitat will get smaller every time to the point of not having food to eat, and irremediately having to face the ultimate dichotomy, resort to cannibalism and kill the other polar bear to survive, or die, wether killed by your equal, or drowned in the sea trying to escape.

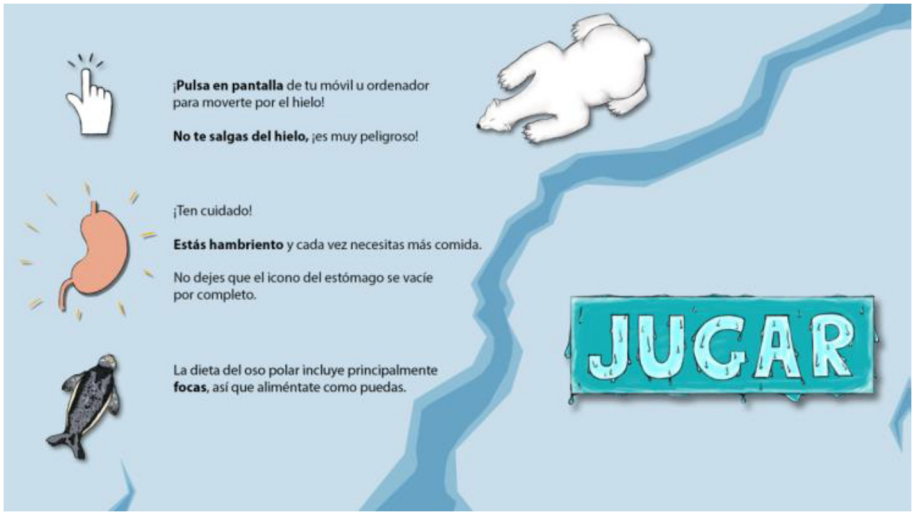
Keywords:
Polar bear, cannibalism, awareness and ecology

Technical Requirements

In case that the attendants want to play the game, they will need a computer or a mobile phone and internet connection to download it. If they are going to play in a mobile device, the game is only available for Android.

Number of participants

Minimum of 10 and maximum 40 participants.



Description

Our workshop is going to be organized in two different parts. First of all, we will talk about our videogame, what is a news game and the creative process for its development.

During the second part, we will interact with the attendants through a short dynamic, in which they will be asked to think about possible ideas or mechanics for a news game, based on a previously selected news.

As it has been already said at the beginning, we will also talk about the new chosen to develop our videogame, giving the public some context about it. https://www.20minutos.es/noticia/4169564/0/el-calentamientoglobal-aumenta-el-canibalismo-entre-osos-polares/ (20minutos, 2020)

Once the context is given, we would like to explain what motivated us to choose this new among all the different options we had.

We were given the opportunity to develop a news game, and we wanted it to be something special, that we really felt as a part of ourselves.

This was found in the research phase of the task, and got us fascinated, so we did a deeper investigation about it. Soon after we started reading more articles, we realized that our own daily actions took polar bears into this horrible situation.

With this weight on our shoulders, we decided to take part of our responsibility and use this exercise to raise awareness through the videogame.

At this point we will speak about what a news game is, and which are some keys for its creation. The process is really interesting, because this sort of game must be done in a very short time lapse, due to the immediacy of the news.

This has a straight connection with the kind of news you can use to base your game on, because not all of them are made to be completed with a videogame. This is a crucial decision at the beginning of the process, because owing to the volatile information that some news are based on, our video game would lose sense as fast as that data changes over time.

The news used to develop a new game, must use information that prevails in a medium/large time range.

As part of the workshop, our team will be glad to share the creative process during the news game's development. We will give detailed information about the design decisions taken, or even why this art is also influenced by the type of game we were making.

We decided to go with a cartoonish art style but keeping the real proportions of what they represent in real life. This decision was made based on the target audiences for which this game was made. On the one realized that it had to be simple, so anyone, a teenager or a person who has never played anything, could easily interact with our game. On the other hand, we had to keep the impact of the new. This news game was published in the webpage of a local newspaper, and we received some data. For example, 80% of the people that get to the webpage do it via smartphone. Thanks to this information, we decided to build the game for mobile platforms in order to reach as many people as possible.

Last but not least, we will relate our videogame with the news chosen and the different design ideas we had.

At the very beginning, the idea was to play with an adult polar bear, constantly followed by its cub, so in the end, the player had to choose between drowning, eating its own cub, or starving.

However, this option, as good as it seems to be, was too troublesome in design and in programming, since there were so many ways this could fail, not generating the experience we wanted. That is how the idea of placing another polar bear in the glacier. This other bear will attack us without hesitation to survive when the glacier runs out of food. This idea was affordable for the time we had for the development.

We also realized that those who got to the website, would not take a long time to leave the site, so the video game had to be easy to understand in less than 10 seconds.

The movement mechanic is pretty simple and easy to learn, because it´s a point and click system, and the initial food amount is enough to, since the first second of gameplay, the player understands the killing mechanic.

However, that was not enough, despite everything we did with the gameplay, a player may feel lost, that is why we added a simple tutorial that explained all the mechanics and objectives of the game.

And the last highlight of our news game, is related to the winning system. You never win at the end of the game. Our main goal is to make the player empathize with the polar bear situation, whose outcome is tragic no matter what you do. Starving, drowning or get killed by your equals. Because the principal objective of a news game isn´t about playful purposes but inform about the topic covered.

Now we are going to get through the second part of the workshop, where the short dynamic will take place.

Now that they have learn what a news game is, they know what we need for it and what is its objective. We will start our short dynamic and give them a new, which will have to think about some mechanics or different ways to create or approach a news game.

We think that this is a good way to put the knowledge they have learnt in the workshop in practice and making the presentation more dynamic and interactive so the attendants don´t get bored and stay focused during the presentation.

Finally, we would like them to ask as many questions as they want related to us as a team, to our news game or just about news games as a topic.

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Website:

Twitter: https://twitter.com/LudursusStudios
Itch.io: https://fertaso.itch.io/supervivencia-polar

Title

Pacversary – Game Design Applied into News Games

Authors:

Raquel Llaneza, Álvaro García, Vicente Cupello, Cristina Rodriguez, Alejandro Pérez and Enrique Maldonado

Institution / Company

Universidad Francisco de Vitoria

Abstract

The workshop is oriented towards undergraduate students interested in the field of news games and their development, as well as people new to the field of game design.

Technical Requirements

Internet connection and imagination.

Number of participants

The exercise we have planned will follow a group dynamic, and we think that about 12 participants (3 groups of 4) will be the most optimal for the exercise to allow for fluid communication

Description

To begin, we will introduce the field of game design and news games briefly, as well as some terminology related to them. Then, we will present the timetable, so that the participants understand what will be done throughout the workshop.

1º THEORY
First, we will briefly introduce videogames and news games, along with the relationship between them, explaining their process of design and development. In five minutes we will explain the activity and the

results we expect the participants to have achieved at the end of the practice.

2º PRACTICE
The participants will have fifteen minutes to complete the template we provide them with for the scope of their news games.

3º FEEDBACK + EXPERIENCE
We want to give feedback to the participants because an iterative process is not only necessary, but a reality in the field of game design. We don't have time to correct their work, thus we plan to have a feedback phase to explain the intricacies of designing a news game to enhance the learning process. Also we want to share our own experience here to complement the feedback. We would explain how we got some visibility and the support form Bandai-Namco and why it was required.

THEORETICAL ASPECTS
A brief introduction to the theory of communication and how to give visibility to your news game (giving the example of our own experience).

Game design (some explanations about how to design the fundamental parts of a game).

Scope of a news game (how to calculate and calibrate the scope of a game, taking into consideration the theory from the Serious Games-Copenhagen company).

WHAT WE ARE EXPECTING
Our goal is to introduce people to the world of communication and video games and that the viewers learn how to inform through a video game, and the importance of managing the game's communication and visibility once published (social media, etc). We expect to acquire a further understanding of the area of news games. We have designed a template for the participants to show them how they would design and calculate the scope of a news game.

Purpose/Goals: To inform as many people as you can about the article/news that the news game is covering. This is also the main success criteria for a news game.

Barriers: One of the main barriers that a news game has is that it is highly recommended for it to be accessible to all people. In addition, it may occur that when the game is published, the news is no longer relevant.

Resources: The elements necessary to create the news game and how these elements will be created/acquired. As previously mentioned, the game's success relies on the news to be relevant during the time of release, thus news games have to be made in a short amount of time. Because of this, any resource or asset that can be reused or adapted quickly, if required, will lead to success.

Initial approach: When making a proposal for a news game, one can use the "six W's" method of investigation to help them have a starting point in the initial design phase of a news game.

What? What is the news about?
Who? Who is going to spread the news?
When? When is the news relevant?
How? How do you play the game and how is it related to the news?
Why? Why is this news relevant?
Where? The method we are going to work with in the workshop is based on the method used in the Serious Games-Copenhagen company for creating serious games (Simon Egenfeldt-Nielsen).

Title

How to use free motion capture data to animate game characters.

Authors:

João Victor Boechat Gomide (jvictor@fumec.br), Marcelo Tannure (marcelo.tannure@fumec.br).

Institution / Company

FUMEC University

Abstract

The objective of this workshop is to show how to use motion capture data, available for free on the web, to animate characters for digital games. The intention is to demonstrate how to find the correct movement data and how to apply it to a rigged character and integrate it with other animations, organically. In order to be able to show the entire workflow for the duration of the workshop, Autodesk's MotionBuilder software will be used. The software already comes with rigged characters and the interface is prepared directly to work with motion capture data. At the end, it will be shown how to do all the wokflow in Blender, highlighting the equivalences of the steps taken to retarget the animation for the character in MotionBuilder. At the end of the workflow, the user will have animated characters correctly prepared for use in engines, such as Unreal and Unity..

Keywords:
Motion Capture, Caracter Animation, Free Motion Capture Data, Digital Game Animation

Technical Requirements

Classes will be taught remotely, using Discord. Students must have installed, on their computers, the educational or trial version of MotionBuilder, as well as Unreal.

Number of participants

20 participants.

Description

The objective of this workshop is to show how to use motion capture data, available for free on the web, to animate characters for digital games. The intention is to demonstrate how to find the correct movement data and how to apply it to a rigged character and integrate it with other animations, organically. In order to be able to show the entire workflow for the duration of the workshop, Autodesk's MotionBuilder software will be used. The software already comes with rigged characters and the interface is prepared directly to work with motion capture data. At the end, it will be shown how to do all the wokflow in Blender, highlighting the equivalences of the steps taken to retarget the animation for the character in MotionBuilder. At the end of the workflow, the user will have animated characters correctly prepared for use in engines, such as Unreal and Unity.

Using motion capture data to animate characters considerably speeds up the production time of the animation, if the motion data does not have a lot of noise and inaccuracies. What still limits the widespread use of motion capture to animate characters is the high cost of technology, as well as, in many cases, the lack of expertise on how to use motion data. New technological solutions have emerged, such as proposals for open source motion capture systems and new ways of capturing motion. However, it is still the mainstream to use motion capture, with the data obtained by optical, magnetic or inertial methods, from precise and costly systems.

The motion capture system, using physical principles of optics, magnetism or inertia, generates motion data in standard formats, to be used in 3D animation software. The data is organized in a hierarchy, which runs through the entire skeleton, with the hip at the top of that hierarchy. In addition to the definition of the hierarchy in the skeleton, the positions and rotations, in the three axes x, y and z, of each node of that hierarchy and each frame are also provided in the files. Each node is the joint that connects the bones. This data is then applied to the character's rigging and the orientations of all joints are corrected and the bones are characterized, either manually or automatically, depending on the quality of the data.

In this workshop, we will use the characters available in the MotionBuilder interface, to streamline the work and allow the objective to be achieved, which is to use the movement data available on the internet to animate any rigged character, in the short duration of the workshop. In an animation using the complete motion capture workflow, the character artist's construction and conceptualization and, mainly, his personality, are the starting point for defining how the capture will be used. Personality means your physical appearance, your basic movements, as well as your actions and reactions to events and other characters.

In case you want to build a library of motion data for an electronic game, you must first make a list of the movements, with the type of framing. If there is continuity between the movements, that is, the beginning of one start following the end of another, this should go into the details of the list. With the list completed, one must then look for the precise movements in the free libraries available on the internet.

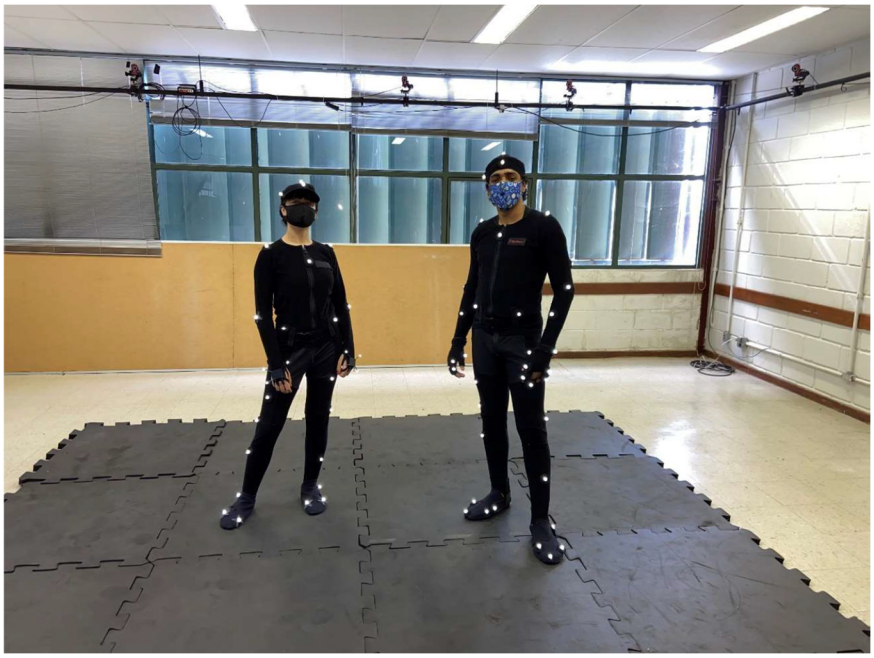
On the web you can find libraries quite complete with motion capture data. Some examples are http://www.mixamo.com/, https://mocap.cs.sfu.ca/, http://mocap.cs.cmu.edu/, http://www.themotioncapturelibrary.com/news/the-motion-capturelibrary and http: / /www.mocapclub.com/Pages/Library.htm. We will initially use the motion data available on the Carnegie Mellon University website, with thousands of movements cataloged and that can be downloaded on any computer. From a previously built script, we will choose and view the files that will serve our goal.

The ideal is to have a detailed script in shots and sequences. From this, the motion library is organized, taking into account the types of scenarios, the characters and the framework, so that the movements that allow to streamline the workflow are used. All of this must be broken down in the decoupage of the scenes. If the character interacts with other characters or objects, they must be divided into parts, according to the interaction and the movement. This makes postproduction work a lot easier when polishing the data. In all situations, a detailed criterion must be adopted for naming the files, since in general they are numerous. This helps both in post-production and when archiving them.

In this workshop, we will use motion data in .bvh or .fbx formats, which are two of the most used in the game development industry. Initially, we will load each chosen motion file into the MotionBuilder viewport and characterize it, that is, we will make the equivalence between the bones of the original capture and the bones of the standard skeleton. Next, we will apply this data to a control rig, bake and save this file, in .fbx format. Then we will load one of the rigged characters available on the MotionBuilder viewport, which are Aragor,

Mia, Gremlin and Pepe, and we will apply the animation that we have characterized to this character. This can be done by means of the tool Story and we can correct any noise using the f-curves. We will repeat this process for two or more animations and learn to integrate them organically, without noticing the change of the animation file, using the ghost, match and f-curves tools. All of these features are found in any 3D animation software and the equivalence between the tools will be demonstrated for Blender. With the animation done, we will bake and save the animation in .fbx format, to be used in engines, such as Unreal and Unity.

MotionBuilder is a software that makes up the 3D animation application suite from the Autodesk company. It was one of the first software developed to work with motion capture data and has its origin in the software of Canadian company Kaydara called Filmbox, launched in 1996. Kaydara launched a native format for motion capture data, the FBX, short for Filmbox. In 2002, Filmbox was renamed MotionBuilder and, in 2003, the company Kaydara was acquired by the company Alias, developer of the Maya software. Alias was purchased by Autodesk in 2006, which incorporated Maya and MotionBuilder into its software suite. The FBX format was then adopted by Autodesk, which integrated it with its other software, such as 3DSMax and Softimage, or Blender.



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INTERACTIVE

Title

Message Across: A word matching game for reward-based in-game behavior change

Authors:

Samuel Gomes (samuel.gomes@tecnico.ulisboa.pt), **Tomás Alves** (tomas.alves@tecnico.ulisboa.pt), **João Dias** (joao.dias@gaips.inesc-id.pt), **Carlos Martinho** (carlos.martinho@tecnico.ulisboa.pt).

Institution / Company

INESC-ID & University of Lisbon & University of Algarve, Portugal

Abstract

Even though several research previously assessed human decision making through games, it is crucial to understand what influences players to commit certain choices. This paper presents a local two-player word-matching game named Message Across, designed to allow both collaborative and competitive in-game behaviors, and study how to mediate different behaviors solely through the scoring system.

Keywords:

Message Across, Word-matching Game, In-game Behaviors

Platform(s)

Developed in Unity and tested on PC & Linux, although we could not deploy the game in our Linux distro, due to a multi-touch requirement.

Description

1. Introduction

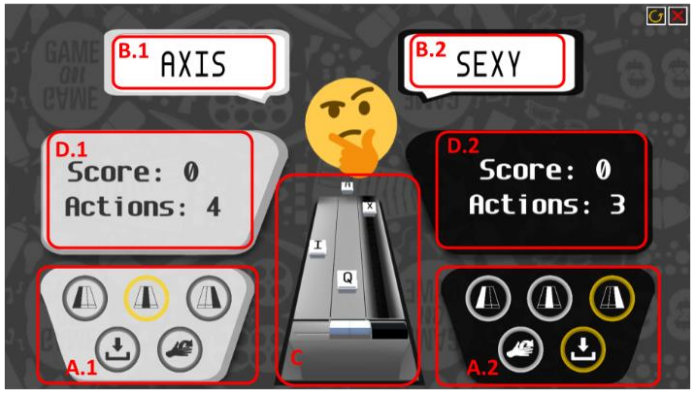

Figure 1: Message Across in-game screenshot.

Recently, games have been applied to study individuals' decision making in environments such as social dilemmas [1, 2]. However, these studies often focus in analyzing players' decisions and strategies. Granting that decisions are often influenced by behaviors within and between individuals, we believe another important aspect to explore is the emergence and promotion of human behaviors through games.

Stepping on that direction, we developed Message Across. Message Across is a game developed with the goal of allowing both collaborative and competitive behavior when two players interact with each other. We wanted the game task to be as neutral as possible, so that the reward system could be modified to promote different types of in-game social interactions. This flexibility made the game appealing for studies involving social interactions. Notably, it has already been applied in recent research [3, 4].

Figure 2: Players Interacting with Message Across.

2. Gameplay and Game Design

The setting for Message Across was developed around the metaphor of rhythm games as Guitar Hero[1], so that it is both engaging and entertaining to play. A screenshot of Message Across is provided in Figure 1. The game was developed for touch screens, and players interact with it through virtual buttons positioned in each bottom side of the screen (areas A.1 and A.2 of Figure 1). An example of players interacting with the game is provided in Figure 2, and a link to a video of Message Across gameplay was added below[2].

Through the course of the game, players try to complete words. Each level presents two words on the top of the screen, one for each player (areas B.1 and B.2 of Figure 1). The game contains three lanes (area C of Figure 1), as well as two markers, one for each player, arranged at the bottom of the lanes. In order to select a letter, the players must position their marker in the lane where the letter is rolling and select an action. When the letter collides with the marker, the selected action is performed. Only the first player that selects an action is able to perform it.

In order to design a neutral game task, we ensure that a word can be completed either by competitive or collaborative actions: each player can either take a letter (advance their own word) or give a letter to the other player (advance the other player's word). Meanwhile, the score system is used to give feedback to the players, to bias their behavior, and ultimately to shape their interactions. For example, to promote individual behavior, the score system may exclusively value take actions. In contrast, to promote mutual help, the score system may equally value give and take actions. We implemented feedback animations [5] to reinforce score changes (Figure 3).

[1] https://www.ranker.com/list/guitar-hero-games/video-game-info
[2] https://youtu.be/hAS9PUVaRlY

The score systems and maximum number of actions per level can be configured by the researchers. Each level ends whenever both players have no available actions. The player scores and available actions are displayed in the game interface, above the players' buttons and below the players' words (areas D.1 and D.2 of Figure 1).

Figure 3: Message Across score change feedback animation. The left player got a 5 points score decrease and the right player got a 5 points score increase.

3. Personalization

The game allows researchers to personalize most of its gameplay elements. Configurations are divided into three categories: *general configuration*, *score system configuration*, and *level configuration*.

The *general configuration* includes player UI colors, the number of available actions per level (defaulted to 4), initial scores, number of levels to execute before the game ends (defaulted to 7) and the ratio of random vs needed letters to spawn on the lanes of the center track (defaulted to 70%). Additionally, researchers can select what log mode to use, between *DEBUG* - logs are printed to the console - and *MONGODB* - logs are printed to an external Mongo DB table, through a connector. Finally, *general configuration* also contains references to the user-defined score system versions, along with prefixes representing them. Researchers can select any score version in-game, by selecting its prefix in a menu displayed before the main gameplay (Figure 4). A configuration prefixed by T (Tutorial, implying no scores for any action) is always added by default.

The definition of a score system version is assessed by the *score system configuration*. The score attributed to a player after performing an action can be parameterized according to the action itself (give or take), whether the letter is useful for the player who performed the action or the other player, and whether the player who performed the action has a lower, equal or higher state of word completion than the other player. For example, the score system can reward a player who advances their task progression and punish the other player at the same time, when both players need the same letter (the score of one player increases by 5 points, and the score of the other player decreases by 5 points, as represented in Figure 3).

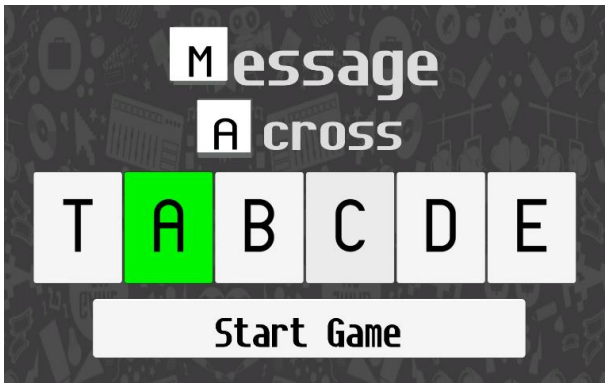

Figure 4: Message Across score system selection menu. Each letter identifies a score system version.

Finally, *level configuration* encompasses a list of available words to complete. Whenever a level begins, a pair of words is picked randomly from a list defined in this file.

4. Demo

The demonstration of Message Across requires a simple setup: a computer and a touch screen. Message Across is played by groups of two participants, each located at one of the sides of the screen (as represented in Figure 2). It is advisable that players first understand and master the game actions and rules through the default Tutorial score system. Afterwards, players can play with other score systems as many levels as the general configuration allows. While playing different versions of the game, players can be left free to interact.

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Acknowledgements:

This work was supported by national funds through Fundação para a Ciência e a Tecnologia (FCT) with references SFRH/BD/143460/2019, SFRH/BD/144798/2019, and UIDB/50021/2020.

Website:

https://github.com/SamGomes/message-across

Title

Candy Loft VR Experience

Authors:

Gustavo Rodrigues Correa
Lucas Diego Gonçalves da Costa

Institution / Company

Faculdade de Ciências Empresariais,
Universidade FUMEC,
Minas Gerais, Brasil

Abstract

Given that real estate developers currently have a considerable financial cost building decorated apartments prior to condominium construction, research is being done into the development of interactive virtual reality mockups to encourage the customer to visit the apartment virtually, reducing or eliminating the costs of building a decorated one. This requires a comfortable, natural and believable experience, with total immersion of the viewer in a virtual environment simulating reality. Research is then conducted on which software and hardware is best for this purpose and make a product that meets this goal. On that aspect, it appears that virtual reality, coupled with real-time rendering has a great power to innovate the real estate industry, offering its customers, from anywhere, the possibility of an immersive and interactive virtual experience to meet apartments that still were not built, without the need to travel to the physical site. As a result, technologies such as virtual reality and real-time rendering are tools with the power to revolutionize markets, and can directly or indirectly impact people's life quality, deserving to be studied and explored in all aspects.

Keywords:

Virtual Reality; Unreal Engine; Architectural Visualization; Real Time Rendering.

Platform(s)

PC, VR, HTC Vive.

Description

The idea is to provide an interactive experience where the viewer becomes the protagonist of the narrative, being in a modern apartment in virtual reality. The focus is on the apartment and its space itself, immersively presenting what it provides to the viewer, who uses virtual reality glasses and a control in each hand, allowing immersion and interaction with the virtual environment in a self-explanatory way it's natural. Introducing this experience to the market, we simulate a visit to a decorated apartment. The viewer can move around walking or teleporting with the controls in hand. Through benchmarking I was able to extract information about the minimum hardware configuration to run the demo smoothly. Intel i3-9100F Quad-Core 3.6GHz with 16GB of RAM and a NVIDIA GTX 1660 6GB 192 bits should take any model of HTC Vive for maximum performance in frames per second.

A more thorough documentation is available at: https://bit.ly/2URX6QC

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Website:

https://vimeo.com/372794737
Download available at:
https://bit.ly/2SlSYHC

Title

Otherworldly Math

Authors:

Andreas Melo[1], Fernando Soares[1], José Carlos Neves[1], Conceição Costa[1], João Frade[1], Guilherme Saturno[1], Lília Marcelino[1], Carlos Santos[2].

Institution / Company

[1]Universidade Lusófona — CICANT; [2]ISEL-IPL.

Abstract

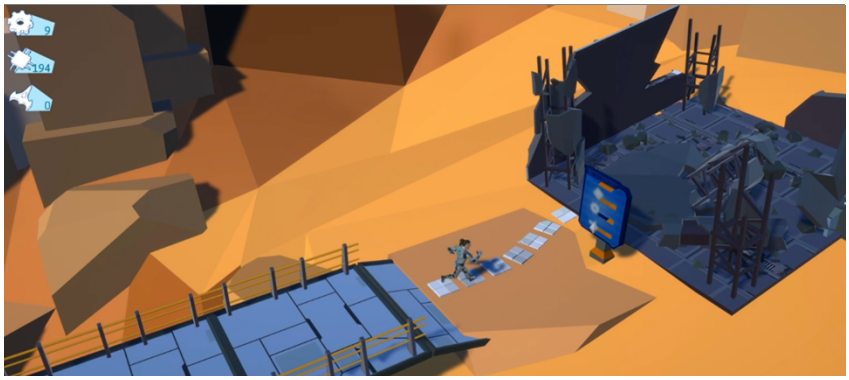
Otherworldly Math is an inclusive research-based educational videogame designed for Deaf and Hard-of-hearing children, being developed under the project GBL4deaf financed by National and European Institutions.

In Otherworldly Math the player controls the Commander, a character in charge of building a space base on another planet. In order to obtain the necessary resources, the player must first build the production plants and then solve challenges inside each of those. By doing that, the player is able to build new production plants and upgrade the existing ones, increasing the resource output. In each production plant one or two mathematical competencies can be improved and, by repeating the necessary actions to obtain the required number of resources, the player develops mathematical dexterity in those areas. Real-time feed-back guides the player through the learning activities, which are integrated intrinsically on the playability. The player uses math skills to solve challenges that emerge organically from the game world and is rewarded with resources that allow progression through the game challenges, as well in acquiring more complex math knowledge. In Otherworldly Math failure is an opportunity to play again, therefore, to learn.

Keywords:
Accessibility, Game Design, Game Development, Games Based Learning, Deaf Children.

Platform(s)

PC (windows 10)



Description

This interactive demo aims at sharing an in-development inclusive research-based educational videogame designed for Deaf and Hard-of-hearing children. Otherworldly Math is a third-person camera game with fixed orthographic perspective, to be played in single-player mode with a cooperative multiplayer option. It's an adventure-puzzle-arcade kind of game, with low-poly design, vivid colours and sci-fi genre.

The game is designed to be a mathematical educational game for formal and informal learning. The player must use mathematical abilities to solve four challenging puzzles in order to build a space base. Each challenge has three difficulty levels, which are designed to provide progressively advanced mathematical knowledge and reward the performance with resources to build and upgrade the space base. Challenge 1 consists of an addition and subtraction puzzle, where the player must add or remove particles of an 'atom' to create a resource. Challenge 2 consists of multiplication and division tasks in which must be defined the number of cars needed to transport the produced gears. Challenge 3, a «turtle geometry» type of game, requires algorithmic thinking and notions of angles and rotations; the player establishes paths in a 5x5 grid by using step-by-step sets of instructions: turn to the right, turn to the left, step left, step right, step forward, step backwards. The 4th and last challenge is about polygons decomposition. Using the tangram construction model, polygons must be placed in the right places to complete the requested tangram figure, then weld them together with the use of cartesian coordinates and thus produce pieces to construct spaceships.

Beyond those math challenges, the player will have to protect the base against space pirates in an epic spaceship battle. To achieve that, spaceships must be built with the same resources needed to upgrade the main character and buildings. This creates a game loop with continuously seek for resources to be applied in base upgrades and build better spaceships to fight pirates. By creating multiple layers of rewards and needs, we ensure the player focuses on fun gameplay, while still having to use math in order to unlock more of the game and improve his base. This approach helps keep a higher interest throughout the gameplay experience.

We conclude this description by pointing out our bilingual in-game tutorial approach as a differentiating factor of this project. Portuguese official guidelines [1] on deaf children education aim at implementing a bilingual education model, guaranteeing linguistic growth and social inclusion of deaf children, so an educational videogame with the goal of being inclusive for the deaf community must be bilingual. From this condition several Design challenges emerge, such as finding graphic solutions, development processes and message content. Otherworldly Math follows an in-game tutorial approach, combining introductory information to the challenge with step-by-step instructions. The introductory panels are bilingual, integrating written Portuguese and Portuguese Sign Language (LGP); in the step-by-step panels that guide the player's intervention in the first rounds, only text is used to minimize disruption to gameplay and facilitate technical processes.

The bilingual approach is consistent with accessibility guidelines for the development of videogames for deaf people. Several authors point out the need to integrate LGP [2,4,5,6] and, concerning to written instructions, is advised to use short sentences and avoid ambiguous or unfamiliar words [2,3,5,6]. These are fundamental principles that were taken into account in Otherworldly Math, which reinforces the inclusive qualities of this research-based educational videogame.

// Acknowledgement: The present study was conducted under GBL4deaf – Game-Based Learning for Deaf Students [PTDC/COM-CSS/32022/2017] project, funded by the Portuguese Foundation for Science and Technology (FCT), Lisboa2020, Portugal2020 and European Un- ion - European Regional Development Fund.

//layout and setup / technical requirements for presential presentation: we will present an alpha version of a standalone game produced with the Unity game engine, requiring a PC with Windows 10, screen and keyboard.

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Website:

//Video trailer for download:

https://www.youtube.com/watch?v=LxgiG_WcxxU

Title

Borderline

Authors:

Sofia Santos (sofia.fls.santos@gmail.com)
Patrícia Gouveia (p.gouveia@belasartes.ulisboa.pt)

Institution / Company

Interactive Technologies Institute/LARSys
Fine Arts Faculty/ Lisbon University

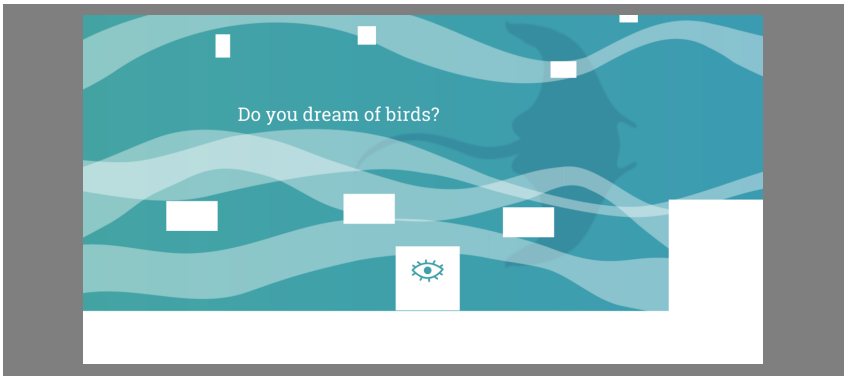
Abstract

In *borderline*, you play as a little cube going for a peculiar walk that will make you face questions of being with yourself and with others. These questions address the feelings of the borderline mental disorder, creating sensations of doubt and emptiness. The soundtrack and animations that accompany the journey will immerse you in an environment of discomfort and confusion that is, at the same time calm, and reassuring.

Keywords:
Art Game, Exploration, Mental Disorder, *Serious Games*.

Platform(s)

Computer (Windows, Mac OS and Linux).



Description

The project *borderline* is an artistic piece in the format of a platformer game that parallels the homonymous mental illness. This disorder causes symptoms of self-image problems and difficulty in engaging in relationships, leading to emotional crisis. It also reveals itself in the form of extreme fear of abandonment, acts of self-harm, chronic feelings of emptiness, tendency to hold grudges, etc. (according to The ICD-10 Classification of Mental and Behavioral Disorders of the World Health Organization). Since the project was developed in a time of confinement that was lived around the world for several months, it is loaded with associations essential to the moment, mirroring, for the author, the observation that the quarantine months hardly diverged from usual routines. Both ideas relate to senses of self-doubt and difficulty in acting.

Positioning *borderline* in the category of *serious games* (games with a serious agenda/about real-world problems) we get to compare it to others like *Dys4ia* (Anna Anthropy, 2012) where the author designed an autobiographical game about her experience as a trans woman undergoing hormone replacement therapy. This game serves as a way to sensitize the unaware public of these struggles, and also to remind the ones who face these same problems that they are not alone. Another project that, to a certain extent, resembles ours is *SuperBetter*, Jane McGonigal's 2012 *alternate reality game* intended to make a positive impact on the player's habits and mental health. These contrast in a way where *borderline* aims to put the player in an introspective state of doubt and concern, instead of creating an environment in real life to help reduce these thoughts.

The interaction possibilities that the medium allows are ideal for giving the user a role in something; give them responsibilities in an environment without consequences for them to question themselves about their choices and have the chance to repeat the journey. The word game is used, but it escapes the expected canons, as it creates an experience in which the player does not lose or win, only reaches the end, collecting memories. For example, in *Everything* (David O'Reilley, 2017), a simulation game in which the player can explore a universe, controlling its various components from subatomic matter to mountains or even planets, the experience in *borderline* is your goal. Also, in *Proteus* (Ed Key & David Kanaga, 2013), the player, seeing the world from a first-person perspective, is free to explore an island, surrounded by different sounds. Exploration, again, is the goal rather than interaction.

Even though the main objective of the game is to create a space for every player to encounter themselves among the experience, it was

shaped by the artist's frustrations, and memories, apparent in the animations that display vectorial forms with semiotic links to real moments. With this in mind, the character is presented in the shape of a cube with an eye - it's a being without gender, intentions or history so that each player can deposit in it theirs. The recurrent representation of hands and eyes creates a balance of comfort and discomfort that is used throughout the game. Both elements can be perceived with contrasting meanings: the eye something that, at the same time, is protection or control, and the hand as something that can be trusted or disloyal. The illustrations that appear in the path are memories of the author and will be, for the player, triggers of others of their own or incentives to create new ones.

During the game, the player is accompanied by a series of phrases and questions that instill introspective actions. These serve, optimally, to those who read them as an incentive to, once again, review their memories, create new ones, or, at least, generate some distinct emotions.

The game's soundtrack is triggered on the launch. It consists of three sections that can be heard in full in the main menu. In the game environment, the introduction only appears once and is followed by four measures that repeat until the player reaches the end, where all dissonances and discomfort are resolved with the final sentence. The harmony used is brimming with ninth chords representing tension through dissonances, sixth chords that create excellent points for resolution, and seventh chords that destabilize the chord and offer a way forward. Complex harmony and repetition cause the player to feel uncomfortable and uneasy.

Upon reaching the end, regardless of the route taken, the game will always end the same way, there are no rewards or punishments. Making parallelism with life once again: death is certain, as is the end of the game. What is done from the time you have is your responsibility. The opportunities used are conditioning each one's experience, as well as the obstacles they face, but not the outcome - this is the message left to the *borderline* player.

To show and play the game it is needed a computer that supports Windows, Mac OS, or Linux and has, at least, an available keyboard (it doesn't require the mouse to play).

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Website:

https://xiasantos.itch.io/borderline

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GAMES FOR CULTURAL INCLUSION: HUMAN, SOCIETY AND NOOLOGY

Diego Mergener,
diego.Phoenix@hotmail.com| ID+ /
Faculty of Fine Arts of the University of Porto, Portugal

Pedro Cardoso,
pcardoso@fba.up.pt | Lusófona University, HEI-Lab & Faculty of Fine Arts of the University of Porto, Portugal

Bruno Giesteira,
bgiesteira@fba.up.pt | INESC TEC / Faculty of Fine Arts of the University of Porto, Portugal

People of foreign nationalities end up facing difficult situations due to the cultural differences between them and the country where they currently live: customs, language, etc. To address this situation, we pose the question of how games and ludic activities value the dissimilarities between people in the social, physical and noological dimensions in their culture in order to promote social inclusion and teamwork in the contexts of academia and enterprises. And how can these games and ludic activities be designed. This work presents an overview of the themes and subjects that involve the design of games and ludic activities to promote inclusion and teamwork, highlighting the relationships of these games with the anthropological cultural triangle proposed by the anthropologist Misha Titiev. It then is questioned whether it is possible for games to focus on more than one dimension of the Cultural Triangle and, if so, how these games can be designed.

Keywords: Game design; Inclusion; Cultural Anthropology; Empathy.

1. Introduction

Games can be excellent tools for working with cultural diversity, whether in academic or in business environments. However, diversity can pose a challenge for teamwork. Levi (2012) asks how is it possible to make different people work effectively together as a team? This restlessness lead us to a question that urges to be answered: How can games and ludic activities value the dissimilarities between people, in the social, physical and noological dimensions in their culture in order to promote social inclusion and teamwork?

Levi (2012) explains that one of the benefits of using a group to propose creative solutions is that these can create supportive environments that influence creativity. The author emphasizes that a diverse team, i.e. featuring demographic, psychological or organizational diversity, is more likely to develop creative solutions than teams that are homogeneous in that sense. Levi also states that a diverse team is likely to have better performance in tasks that require decision-making, problem-solving and creativity.

It is in this context, our research – that is in its initial stage – intends to explore the three cultural dimensions proposed by the anthropologist Mischa Titiev in order to understand how games can act as tools for foster cultural diversity, social inclusion and teamwork, namely, in enterprises and academia.

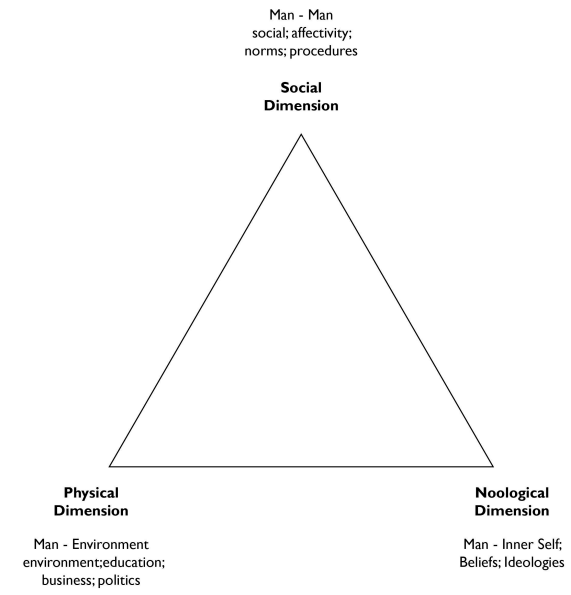
2. The cultural triangle

Titiev (2000) presents three cultural dimensions: the social, the physical, and metaphysical. This last one, was rewritten by the research team as noological. The *social* dimension refers to the bidirectional interaction between Man and Man, his relationship with other people, his affectivity and feelings. In this case, empathy may be used as a tool to stimulate actions. Singer and Lamm (2009) refer that empathy happens when a person perceives or imagines the feeling that the other person is feeling and partially feels that feeling. And according to Bloom (2017), empathy can lead us to actually accomplish the action itself.

The physical dimension refers to the interrelationship between Man and his Environment and rules, his business, leisure or educational contexts. It is about the social inclusion of man in the environment. According to Heidrich (2020), inclusion means combination, understanding, involvement and incorporation of the person in his space. As Lee (2010) explains, the concept of social inclusion encompasses several interconnected factors such as social networks, social and occupational participation, including education, housing and positive factors in lifestyle.

The noological dimension concerns the interaction between an as the Inner Self, his beliefs and ideologies, his cultural heritage. Regarding the notion of culture, Souza (2008) explains that it consists of a list of categories such as religion, economics, etc.. He argues that, in historical terms, culture turns out to be a social heritage, something passed onto future generations. Figure 1 presents the three dimensions of the Cultural Triangle.

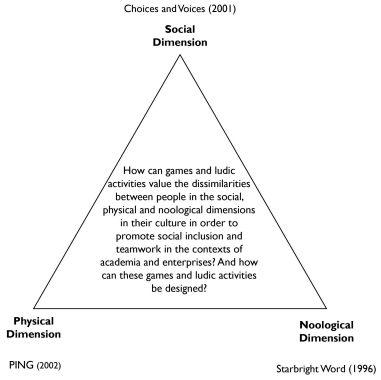
Figure 1: Cultural Triangle of Project based on Marconi and Presotto (1987), Titiev (2000) e Lúcio Souza (2008) about components and notion of culture.



3. Games and the cultural triangle

Some games have already been developed and tested with the aim of promoting social inclusion and interactivity. PING – Poverty Is Not a Game (2002) was designed to sensitize adolescents to issues related with social exclusion and poverty (Lizzy et al. 2012). Choices and Voices (2001) was designed for teenagers to reflect on issues of various social origins such as social exclusion, bullying and violent behaviour. This game focuses on developing awareness among young people, awareness of the similarities and differences they encounter (Lizzy et al., 2012). Starbright Word (1996) is a gamified platform that is aimed at seriously ill children. This platform offers interaction between users, mutual support and a sense of belonging in people in situations of serious illness (Lizzy et al., 2012). The positioning of each game in the cultural triangle can be seen in Figure 2.

Figure 2: The relationship of the games with each dimension of the cultural triangle.



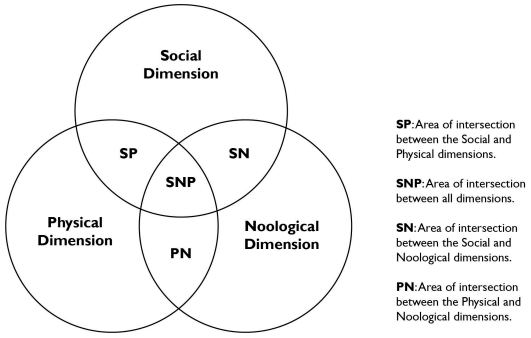
4. Conclusions and Future Work

It is this anthropologic conceptual framework that underpins our epistemological work, understanding and mapping the cultural dimension in an anthropological perspective and the mechanics, dynamics and esthetics of ludic activities, like games, as tools towards a more inclusive society.

Games can contribute to social interaction between people, having relevance in the influence of empathy and social inclusion in the formative and entrepreneurial contexts. In this case, it is believed that social interaction can be influenced and trained to promote engagement between culturally different people, valuing their dissimilarities and providing empathy and teamwork between people in different contexts such as academic and business. It is also believed that these games and ludic activities can generate a network of tools that provide reflection, discussion and critical thinking related to the topic of social inclusion and behavior change within academic and business organizations.

As for future work, we will seek to understand how to identify design principles valuable for designing games and ludic activities in articulation with the three anthropological dimensions of the cultural triangle interconnected. Figure 3 presents a diagram of this questioning. The numbers indicate the places where each dimension is related to each other according to the issue highlighted above.

Figure 3: Reflective diagram on the question of having games focused on more than one dimension of the Cultural Triangle.



Can we have games focused on two or three dimensions of the Cultural Triangle at the same time? How can these games be designed?

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VIDEOJOGOS 2020
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THE PROGRESSIVE PENETRATION OF DATA ANALYSIS AND DYNAMIC DESIGN ADJUSTMENT IN GAMES: A JOURNEY THROUGH ADAPTABLE EXPERIENCE

Andrés Olmedo Moreda, andresolmedo0@gmail.com | Universidad Francisco de Vitoria, Spain

Héctor Puente Bienvenido, hector.puente@ufv.es| Universidad Francisco de Vitoria, Spain

Abstract: The design systems used in video games are in constant optimization and evolution towards a fully adaptive user experience. They are applied both in the gaming medium and transferred to the most varied experiences, through hybridization of the digital and physical world or without it. These innovations respond to the demands of a growing audience, and therefore, one made up of people with unique characteristics. Video games as cultural devices are been adapted to users through tools that allow monitoring and analyzing the performance or player's tastes in order to adjust and tune user experience. Dynamic Design Adjustment not only allows the game to be adapted in real time based on the decisions and behavior of the player but also favors the enjoyment and social inclusion, without forgetting the capacities and possible limitations of the users, thus following the Design Justice approach. We carry out this research on the most relevant trends in Dynamic Game Adjustment through a methodological triangulation that combines in-depth expert interviews and a systematic review of games and the latest dynamic balancing and analytics tools available to game developers.

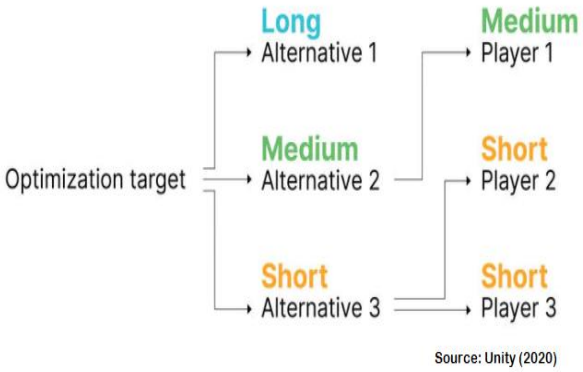
Keywords: User Experience (UX), Data Driven Design, Dynamic Design Adjustment (DDA), Dynamic Game Balancing, Adaptable Game Experience.

Introduction

Traditionally as a medium closed to predetermined systems, video games and its social contexts have been intertwined and merged with the reality of day to day. From a few years to the present, although with past attempts limited by technology, as in Tempest (Atari, 1981) and God Hand (Clover Studio, 2006), a design approach that allows the experience to be adapted to the player's interests has emerged. As has been demonstrated, usability is a key element in interactive systems (Maguire, 2001), so the development method, called Dynamic Design Adjustment (DDA) [1], has been proven successful in the medium, improving the performance [2] and the engagement of the players [3]. As pointed out by Missura and Gärtner [4], the ideal video game should adapt its difficulty dynamically based on the player's performance. This article pretends to highlight the great potential DDA has, and the lack of implementation and attention it is getting. Especially regarding one of the most vanguardist sector of video games, this is Virtual Reality (VR) and Augmented Reality (AR).

For a correct implementation of the DDA, Andrade et al [3] presented three basic requirements: the game must identify and adapt itself to the initial level of the user; the game must track the evolutions and regressions of the player in his performance; and finally, this adaptation or adaptations must seem credible.

Adjusting the behavior of NPCs to make them less aggressive, adapting the number of enemies in an environment, as well as their health or damage values, or increasing the recovery speed of the health bar are some alternatives and design decisions applied in studies [6]. As well as applying it to favor the user experience in matchmaking [7]. But its use is not limited to mechanics, narrative is also able to be applied [8] adapting the narration to the player's profile. Graphics engines like Unity already have their own tool to implement dynamic design and make it more accessible for development studios. Thus, Game Tune and Unity Analytics are positioned as a dissociative element of DDA and high-budget video games, as Unity is one of the most used engines for video game development.



Source: Unity (2020)

Corporations such as IBM also have DDA systems based on machine learning, as is the case of IBM Watson, which through algorithms, in constant learning and adaptation, allows the development of unique systems for each player, individualizing the experience. This tool has been used and fine-tuned by the Francisco de Vitoria University during the development of a serious game based on Natural-language understanding (NLU) aimed at training medical students in clinical anamnesis skills to promote and improve the performance of Medicine degree students.

This approach opposes the traditional vision of the video game as a fixed and pre-designed experience, without adaptive measures to the behavior and interest of the player, as can be observed in the GDCs of different video games, such as Prince of Persia (Broderbund, 1993), Grim Fandango (Lucas Arts, 1998) or Planescape: Torment (Black Isle Studios, 2009).

But the focus is not only located on the adaptation of video games to the player, but on how this interaction is carried out. With, possibly Niantic and its video game Pokémon GO (2016) as the maximum exponent, the trends of video games have been observed to leave the digital medium and merge with reality. Pervasive video games have been integrated, taking the mechanisms and dynamics of prior and 'classical' games to other formats. AR is one of them, and it is acquiring new titles, such as Five Nights at Freddy's AR: Special Delivery (Illumix, 2019), Shin Megami Tensei Liberation Dx2 (Atlus & Sega, 2018) or the currently in development The Witcher: Monster Slayer (Spokko, TBA), which mean there is an interest in developing and improve this kind of experiences. In a more established way, VR has also been receiving media impact. In addition to owning several hardwares from different companies, such as Oculus Quest and its successor Oculus Quest 2, HTC Vive, Sony PS VR or Valve Index VR, to name a few, there are projects from developers with experience in the field, such as Hitman 3 (IO Interactive, 2021) or Half Life: Alyx (Valve Corporation, 2020).

In a more social line, proposals such as Sony's PlayLink are interesting. "A new way of playing" is situated as the title of the website. The intention of PlayLink is to bring up the attention to a more social way of playing, putting aside solo experiences and embracing the video game as a means of entertainment to a group of people in the same room. Games like That's you! (Wish Studios, 2017) or Hidden Agenda (Supermassive Games, 2017) are part of this video game initiative, which uses mobile phones as an intermediary between players and the game. Inclusivity in video games does not only appeal to groups. Following the Design Justice or Universal Design method [9,10], Microsoft put on sale an adapted gamepad, called Adaptive Controller for people with motor functional diversity, which makes it easier for more people to enjoy this medium.

But gaming systems have permeated their environment and now there are gamified and data-driven experiences in devices such as museum tours or dating apps. Prado Museum in Madrid has an interactive room (number 39) where VR is used in order to interact with art pieces, again leaving an imprint on the importance of this new technology.

In conclusion, an intention has been found due to the ubiquity of the video game, breaking the classic barriers between context and platform, to be found everywhere and with the option of no stopping gaming; in addition to a demand for memorable experiences, which consist of living an experience rather than consuming a product or story, but with a certain focus at Universal Design, trying to attract the widest possible audience. Finally, the methods are progressively approaching to an increasingly immersive experience based on data analysis, what we could call Peak Immersive Experience, using embedded metrics in devices such as AR or VR, which seem to be the mainstream methods of innovation gaming. Thus, we encourage video game designers to take advantage of this hardware paradigm change and establish DDA as a must-have from now on. Starting a User-Centered Design approach that will benefit both players and developers.

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A USER EXPERIENCE STUDY IN A VERTICAL SLICE VERSION OF A VIDEO GAME

12 th INTERNATIONAL CONFERENCE on VIDEOGAME SCIENCES and ARTS

Pedro Inácio
pmaiwow@gmail.com
Hei-Lab - Lusofona University, Portugal

Guilherme Saturno
guilhermebsaturno@gmail.com
CICANT – Lusofona University, Portugal

Lilia Marcelino
lilia.marcelino@ulusofona.pt
CICANT – Lusofona University, Portugal

Abstract: The present work was carried out to conduct a user playtesting to determine players' interaction with a vertical slice version of the video game 'Otherworldly Math'[1], developed in the project entitled "GBL4deaf- Game-based Learning for Deaf Students"[1] to support mathematics learning for deaf and hard of hearing students. Five hearing boys, one Portuguese and four Brazilian, varying from 16 to 18 years of age participated in the study. A usability questionnaire were applied before, and after participants played the vertical slice. Before playability, to determine their previous experience with video games. After playability, to collect data about participants' overall experience with the prototype, followed by the application of an engagement questionnaire to gauge the state of the user experience. Due to the Covid-19 present scenario, the user playtesting was monitored by the observers, using a video chat platform with screen sharing. During playability, observers noted the players' interactions in the game, filling an observational grid. The data collected was analysed and design problems identified. The results showed that the prototype built a positive user experience, albeit with some areas needing to be improved. Some players had their progress halted by confusing explanations the vertical slice gave to them. One possible solution proposed was simplify the explanations of the various aspects of the game, especially in the last section of the vertical slice, where most of these issues appeared. In general, the usability playtesting showed that the vertical slice version of the video game caught the interest of hearing individuals that is outside the target audience.

Keywords: User Playtesting, Engagement, Vertical Slice.

Introduction

While developing video games, the evaluation of users' experience must be considered continuously by performing tests with prototypes in order to improve the videogame [2, 3] . The usability playtesting should run various times in different stages of development. This study was carried out in the scope of the User Experience Design course unit in the Videogames bachelor, the goal being to evaluate a vertical slice of the 'Otherworldly Math'[1] videogame of the research project "GBL4deaf" [1], provided by the course unit's teachers. The goal of the playtest is to obtain feedback from participants about their game experience with the vertical slice and to propose solutions for those areas that could be improved upon, even if a good user experience is verified in them.

Method

Participants

The participants involved in the tests were five boys with ages between 16 and 18 years old. Two participants with 16 years old. Other two with 17 years old and one with 18 years old. The participants attended the 11th grade (Portuguese educational system) and 13th grade (Brazilian educational system, equivalent to 12th grade). The nationalities of the participants are: One Portuguese from a public school and four Brazilians from a federal public school where students' entries are selected based on meritocracy.

Materials

Vertical slice of 'Otherworldly Math' [1]. Designed and developed by the GBL4Deaf [1] research project, but still in an alpha version, 'Otherworldly Math' is a single-player Sci-Fi Adventure and role-playing video game, with a low-poly art style and an isometric camera with an orthographic perspective developed in the Unity game engine for Windows PC, that aims to challenge the mathematical capabilities of the player in order solve various puzzles**.**

Engagement Scale [4]. The questionnaire measures the level of engagement perceived by individuals in playability activity. The scale contains 42 items with 5-Likert points of agreement (1= Totally disagree to 5= totally agree). The items are divided into the five factors: Challenge (15), Control (8), Immersion (7), Interest (6), and Purpose (6). *Challenge* items are divided in three sub-factors that measures the *Motivation* to complete the activity (3 items); the perception that individuals have about what the challenge involves, i.e. *Clarity* (5 items) and the individual's perception that the activity is *Achievability* (7 items). *Control* evaluate the levels of choice of actions available to the player. *Immersion* is the perception of how involved the player feels in the activity that is occurring. *Interest* involves the intrinsic interest in the activity. The fifth factor *Purpose*, is about the individuals' impression of how valuable the activity are, if it is worth the time investment and if the feedback given by it is usable. The items were also grouped in three new factors to refine the measure about: Clear Objectives *(*7), Sensation of Control (6), and Immediate Feedback (3). *Clear Objectives* measures if the objectives given to the player are easy to understand, not to be confused with, but being an indicator of the clarity of the challenge. *Sensation of Control* is related to the player feeling a tighter grip on the broader situation he or she is put into by the game. *Immediate Feedback* pertains to the visibility of the effects of their own immediate actions on the game world to the player, to understand if these are well communicated in their due time.

The 'Got it/Don't Got it' observational grid [5]. The observational grid aims to determine if the players understood other aspects of the game, even some trying to verify if the player could find a way to bypass any of the known bugs of the vertical slice, in case they happened, without restarting the game altogether.

Usability Questionnaire (pre- and post-questions). The pre-questions were used to gather more information about the player's preferences, and their experience with games, while the post-questions were applied to address more specific topics in the vertical slice in order to verify its consistency.

Usability Test Script. The purpose of the script is a guideline to help testers predicted situations during test sessions.

Electronic Device. Laptop and PC's with Windows 10 software in Zoom Platform.

Procedure

The procedure went through various phases. The initial being the preparation of the materials and documents needed for the study. Next, the search for participants ensued. Pandemic and subsequent quarantine, greatly hindered the ability to search for participants. The solution was a convenience sample constituted of individuals that were outside the target audience with different ages. After the participants were selected, informant consents were signed by parents and participants. Initially, six students were selected, but one of the participants had to be nullified before any data be collected. The Zoom platform was used to conduct all usability sessions.

Results and Discussion

CHALLENGE: In terms of Challenge, participants reported *motivation* to complete the game activity. More over, there is an almost total concordance by players (83 %) that the vertical slice version of the video game has *clear objectives* and that the game activity is *achievable* (see Fig. 1). The results indicated that the vertical version was considered accessible by the players, which is an inevitable by-product of the participants collected having to be not only older than the target audience but not suffering from the same affliction. Despite this, the fact that the vertical slice piqued the interest of players even outside the target audience might mean there is a broader appeal to the project.

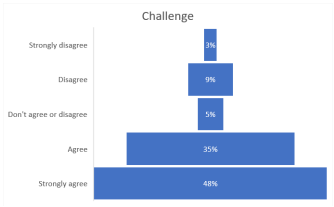

Fig. 1. Participants' feedback about Challenge.

CONTROL: Besides the players agree that they feel control during the game activity (60%), the sensation of lack of empowerment is denoted from around 25% of the players (see Fig. 2), that comes mainly from the lack of a broader array of actions available to the player, which generates a feeling of lack of quantity and diversity in the types of activities available to the player. The results indicate that there is still room for improvement in this aspect, by diversifying the tasks and actions available to the player, making not only for a more compelling and exciting game but also allowing a stronger feeling of control over the character.

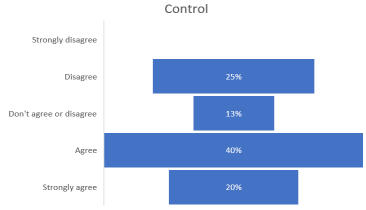

Fig. 2. Participants' feedback about game control perception.

IMMERSION: The Immersion factor show a high rate of concordance (78%). That might mean that participants feel absorbed in the game activity, and the sensation of immersion is present, even seeming to be close to reaching the flow (see Fig. 3). Crossing the data gathered with testers observations, most players who did not report the felling of sensation of immersion seemed to have an aversion to the graphical style of the game, which made it harder for them to connect with the game activity. The results may indicate that the flow is reachable. But at the same time can the flow state can be ruptured by the lack of empathy towards the graphical style presented, showing that this psychological state is one that can be broken by a variety of factors that do not necessarily impact the gameplay directly.

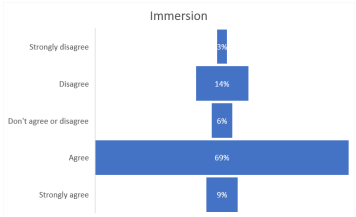

Fig. 3. Participants' feedback about their immersion feeling in the game activity

INTEREST: There is a high concordance (73%) regarding the interest shown towards the gameplay, possibilities, and context the player is inserted into (see Fig. 4). However, there is still some indifference and discordance (26%) about players intrinsic interest in the game activity (see Fig. 5). The low levels of agreement might relate to other aspects observed—for instance, the lack of options presented to the player and to the game graphical style dissatisfaction.

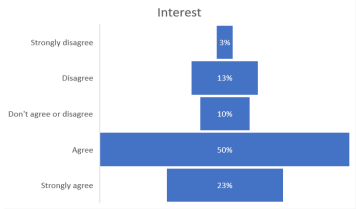

Fig. 4. Interest reported by participants in the game activity

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PURPOSE: There is a near-total concordance in the participants that the game activity is worthwhile (96%) (see Fig. 5). This result might indicate that the game activity makes sense in the context of the narrative. The 'Why?' of the game action is easily understood in the context of the game as well. The test audience shows that they were willing to let themselves taking with the flow of the game's activities which reveals that the purpose is a substantial factor, what not requires any improvement. Moreover, after grouping the items to analyse whether immediate feedback is perceived as having a game value, the results show that participants reported almost 30% of total discordance (see Fig. 7). Discordance seems to occur related to the failure to communicate the effects of players' actions, both in the short and long term. Adjustments and improvements are necessary to the way the results of the players' actions have in the game world, within the context of the game itself.

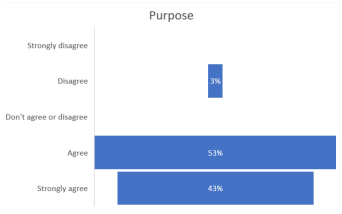

Fig. 5. Purpose of the game activity perceived by participants

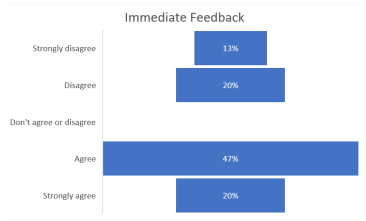

Fig. 6. Immediate Feedback given by the game perceived by participants

Final Considerations

The present work aims to analyse the user experience of the 'Otherworldly Maths' vertical slice to determine if it allows an adequate level of psychological engagement in-game activity. If not, some solutions are proposed.

Some players reported the lack of control over the characters actions and the lack of immediate feedback. These results may relate to the players' avatar in-game - being it movement, their interactions or not enough ways to reach out to the game-world that the players is inserted. Therefore, the most flexible solution would be to work in both immediate and long-term feedback. Immediate feedback would be the reaction right after an action is finished, going from pressing a UI button and playing an animation, to the character base movement and the acceleration/deceleration over time in a transition between a walk and a run cycle. As for the long-term feedback, it would be planting a seed and over a few game sessions observing the growing process of a tree. Accurate instant feedback minimises confusion by communicating to the player what his actions are doing in that exact moment. On the other hand, long-term feedback will show the consequence of those actions in the future, even though it doesn't interfere with the gameplay because it is enough to make the player feel part of that world. In sum, by minimising the necessity to think over immediate actions and maximising the curiosity over long-term actions, the flow state would be more easily reached while extending its duration. Despite the results and solutions proposed to improve the vertical slice version of the game, some limitations are present in the current work.

The convenience sample and the small sample, the use of on-line sessions, the different characteristics of the target audience may influence the results. Future playtests with a larger number of participants and with similar characteristics of the target public related to age, grade, besides a group of deaf and hearing students, are necessary.

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INTERFACE UX: EVALUATING THE GAMEPLAY EXPERIENCE IN AN EDUCATIONAL GAME

Ana dos Santos,
an.santos95@hotmail.com | Hei-Lab – Lusofona University, Portugal

Catarina Matias,
cisa.matias@gmail.com | Hei-Lab – Lusofona University, Portugal

Lilia Marcelino,
lilia.marcelino@ulusofona.pt| Hei-Lab – Lusofona University, Portugal

Abstract: The current study was conducted for the User Experience curricular unit by two students of the Videogames course at Lusófona University, Portugal. The present work aims to evaluate a vertical slice version of the educational video game Otherworldly Math to obtain players' reactions regarding the games' capability of exposing information through its interface. Four participants participated in the study with 11, 16, 18, and 26 years old. The design problems noted by observers and players' feedback are based on the game's way of exposing information through its interface which interferes with the player's gaming experience. Proposed solutions are presented to improve the playability.

Keywords: Game User Experience, Educational video game, Engagement.

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Introduction

The present work focuses on Game User Experience (UX). Game UX is a process of supporting the user's behavior by creating a product that provides meaningful and relevant experiences to users. "This process involves the design of the entire process of acquiring and integrating the product, including aspects of branding, design, usability, and function" [1].

It is essential to focus on the in-game interface and how its information is exposed to the players. By analysing and observing the results obtained from an observational grid, along with the player's feedback questionnaire, it was possible to get a clear understanding of design problems that might occur throughout the playability.

The main goal of this study is to identify interface flaws by analyzing the games' communication with the players. After identifying design problems that might be affecting players' gaming experience, solutions to enforce this communication are proposed.

METHOD

Participants

Four Portuguese students participated in the study. The average age was 17,75 (SD = 5,4). Two boys of 11 and 26 years old, who attended 5th grade and university respectively, and two girls of 16 and 18 years old, who attended 9th and 11th grade, respectively. The scholar institutions are in the metropolitan area of Lisbon. All participants shared different experiences with video games.

Materials

- **Otherworldly Math** is an adventure, single-player, third-person video game that presents mathematical educational challenges. The players add or remove particles of an atom to be able to create resources for their space base. The game is sci-fi themed with a low-poly art style. It was developed in Unity for PC under the research project GBL4deaf. A pre-alpha version was used in the present study.

- **Engagement Scale [2]** is a 42-item questionnaire to measure game engagement with 5-Likert points scale in which responders specify their level of agreement (1= strongly disagree; 5= strongly agree). A sixth Likert point was added to the original scale - 6 = Not Applicable (NA) in case of uncertainty. The items are divided into five factors: Challenge (15 items), Control (8 items), Immersion (7 items), Purpose (6 items), and Interest (6 items). Challenge evaluated the emotional state of the player through comprehension of the objectives that the game presents, and its tangibility. Control measures the players' in-game options. Immersion aims to understand whether the game can keep players absorbed in the game world. Purpose intends to obtain data that justifies in-game behaviors. Interest evaluates the perception of the player about the game's capacity to keep the player interested in the playability.

- **Observational grid [3]** is an observational grid used by observers during playtests to rate experienced players and to take notes of whether the player did or did not understand specific game mechanics and concepts. Five columns compose this grid: First, game moments - a list of predefined items concerning a particular moment/situation in-game; Second, Got it/Don't got behavior rating; Third, notes = general observations about players' actions; Fourth, Experience = a 5-Likert points scale about the experience of the player in each game moment (1= no experience at all; 5 = excellent experience) based on the observations for each moment; and fifth, Notes = for developers. The grid's purpose is to take notes about behaviors/situations that will help identify and justify problems, compare those with questionnaire results, and find which moments are straining the gameplay.

PROCEDURE

After informant consents by parents and participants, participants played a pre-alpha demo, which is a preliminary build of the video game Otherworldly Math. During the playability, players actions were observed, and after playing, they were asked to fill the engagement questionnaire.

RESULTS

Firstly, we evaluated the players' opinion about the clarity of the proposed game which showed that all players answered without resorting to the "Not Applicable" (NA) option. Therefore, the results add up to 100% of answers, with a 1% round-off error margin.

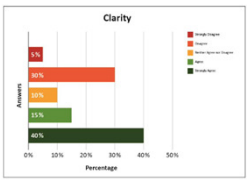

Fig. 1. Represents the Clarity factor, which is the understanding of the main game functionalities and its mechanics.

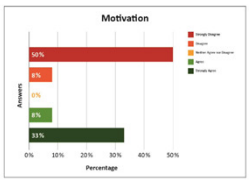

Fig. 2. Demonstration of the level of motivation the players have while playing the game.

Clarity (see Fig. 1.) demonstrates how players agree on the clarity of the game – its objectives and mechanics. Even so, 35% of "Disagree" and "Strongly Disagree" negative answers take more than half of the value of 55% of positive "Agree" and "Strongly Agree" answers. By observing the Motivation factor, which is directly linked to frustration, the data obtained is less positive. It shows 58% of negative "Disagree" and "Strongly Disagree" responses against 41% of positive "Agree" and "Strongly Agree" responses (see Fig. 2.).

The lack of neutrality shows how players had no doubts about how they felt while playing. Although the game is understandable, there are elements in the gameplay that prevent the player's motivation. The number of notes taken during the test shows that it is safe to say that the information given by the interface is one of the contributing factors for player demotivation.

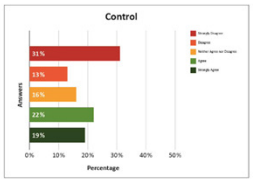

Fig. 3. Control measures the control a player has in-game with the options available.

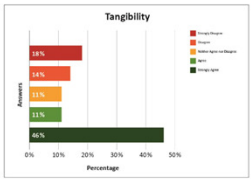

Fig. 4. Tangibility stands for the comprehension and accessibility of the tasks/challenges presented in the game

Control shows 44% negative answers against 41% positive answers (see Fig. 3.). It is important to note that "Strongly Disagree" answers are more prevalent than "Disagree" and "Agree" answers are more prevalent than "Strongly Agree" — indicating a rising negative trend. These results show how players do not feel that they have sufficient control over the game or their character. Some testers also had difficulties in moving the game character in the available space in- game.

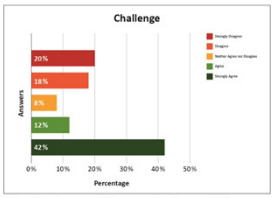

Fig. 5. Evaluation of the emotional state of the player through comprehension of the objectives.

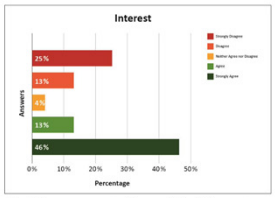

Fig. 6. The measurement of the capability of the game to be able to keep the player interested while playing.

The Challenge and Interest complement one another (see Fig. 5. and Fig. 6.). The Challenge results demonstrate 54% positive answers with a prevalence of 42% "Strongly Agree", indicating that the game is perceived as a challenge.

The Interest chart (see Fig. 6.) presents 59% of positive answers against 38% negative ones. This result indicates that the players were interested in the tasks given and wanted to succeed. However, 25% of "Strongly Disagree" answers indicate a flaw in the game's communication system with the player. Just like in Motivation (see Fig.2.), the lack of feedback and the lack of important information on the menus in key gameplay moments — such as the atom addition activity — affects the motivation to continue, interact, and reduces the excitement for upcoming challenges in the game.

DISCUSSION

The results showed that the game has some problems with how it communicates with the player through its interface. This conclusion came into question because of repetitive situations in the game where players felt that lack of communication, making them feel confused. However, they have shown that it is clear what to do to complete a task. Nonetheless, some factors are leading them to frustration which is interfering with the interest they have on the game. Further analyses of the results were needed to comprehend and understand this issue, and through them, the following conclusions emerged.

Giving players the possibility to skip the tutorial, without having an obligation to see the video tutorial until the end, is a solution to avoid impatience. Another proposed solution for this matter is, to give them the option whether they want to be accompanied by a tutorial or not, which can turn the experience positive for them by ensuring that the activity does not become exhausting over multiple gaming sessions by repeating the tutorial over again.

Also, important to mention is, how the notifications and pop-ups bars blend in with the game's environment which can be solved by changing the colors and shapes of the User Interface to distinguish itself from the background. This solution will help to get the players' attention to the right place. An obvious example is a blue bar in the final task of the game where the player needs to consult that bar to know how many atoms he needs, to create matter. This bar often goes unnoticed by players due to its screen position and the similarity of the colors between bar and background, which goes against its purpose as an indispensable information indicator.

As a final consideration, the game does not present any kind of misunderstandings when it comes to comprehending its functionality, objectives, and mechanics. Still, it fails on exposing the necessary information the player needs while playing, meaning that the information shown (in terms of UI) is neither clear nor available enough. The player understands how to make positive logical decisions, but the game does not give enough feedback to prevent confusion and frustration. It is necessary to demonstrate to the player that everything they need to accomplish their goal is "at hand" to avoid displeasure and loss of interest.

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COART:
MIMICKING PALEOLITHIC ENGRAVING

José Gabriel Lopes,
jsgabriel.lopes@gmail.com |
Instituto Politécnico de Bragança,
Portugal

Bárbara Barroso, bbarroso@ipb.pt |
Instituto Politécnico de Bragança,
Portugal

Abstract: CoArt is a digital game under development in a co-creation process with the Côa Museum, to promote knowledge of palaeolithic art heritage present in the Vale do Côa region of Portugal. One of the project's aims is to enable the player to experiment with techniques and art motifs connected to this heritage. For this purpose, the game offers the player an engraving mode. This poster briefly expands on the mechanics and gameplay being designed for this effect.

Keywords: Virtual Heritage, Serious Games, Palaeolithic, Côa Valley.

Introduction

The Côa Valley is home to the largest open air palaeolithic rock art site in the world. Archaeologists have made astounding discoveries there, but have found that transmitting them to mainstream audiences can be complex.

Experimental Archaeology Workshops (EAW) are able to recreate objects, practices, and techniques simply and accurately, but require effort and a lot of time to host. Most of the public ends up not having this experience. [1]

Recreating a Rock Art Engraving EAW, CoArt lets the player try and learn engraving techniques, the same way as our ancestors thousands of years ago, in any mobile device on the palm of their hand.

Methods

Player-Centric Design is a powerful method to focus design decisions. [2] Children aged 10-12 were selected as primary target audience considering school programmes and museum visitation statistics.

Mechanics were defined based on concrete archaeological evidence on engraving techniques, by Côa's scientists [3, 4, 5], and implemented with the target audience specificities in mind, based on developmental psychology. [6]

Fig. 1 – Engraving Interaction Mode

Direct and Indirect Pecking, Abrasion, Incision, Scraping, are all engraving techniques documented in the Côa Valley [3, 4, 5], faithfully recreated in our virtual rock canvas.

Target audience's psyche, combined with their familiarity with mobile devices, and the intuitiveness of the devices themselves, led the design of these engraving mechanics to specific motions. (Tapping, dragging, multiple touches, etc.)

Fingers become tools, those virtually abstracted techniques are represented iconically by symbols of their physical engravers, and vicariously by the motion employed.

Fig. 2 – Engraving Techniques on Virtual Canvas

Entertainment and fun are at the core of what makes a game a great learning medium. [2, 7] An easy way to achieve this with our audience is through a challenge dynamic.

Our creative-expressive gameplay is given new sense through challenge: the player has to draw palaeolithic fauna, over outlines, by memory, by eye.

The resulting engraving is compared by the software against a previously defined target image, a real Côa engraving, given appreciation through UI feedback, and finally scored, letting the player know how he/she fared compared to the real thing.

Conclusion

CoArt's main goal is to teach, in a participatory manner, the nuanced history of the palaeolithic. For the player to learn what tends to live only within archaeological research and jargon, he/she needs to experience it first hand.

For digital archaeology like this to become virtual cultural heritage, we need to not only present the recreated objects but more importantly their *milieu*. [7]

Thus, like Côa's rocks intentionally left in place, the engraving interaction mode is put in cultural perspective with a visual novel mode. The engraving challenges the players go through are story beats and narrative triggers.

The player takes part in the historical events around the engraved rocks. Both in the distant past, by travelling back in time, and in the '90s when the intrepid team of archaeologists fought for the preservation of Côa's open air sanctuary.

The engravings he/she does stay there for posterity, on a virtual rock face, indistinguishable from the real ones, as he/she slowly becomes a Côa Artist…

[CoArt is currently on a test phase with a target audience sample group.]

Fig. 3 – Palaeolithic Visual Novel Character

Fig. 4 – '90s Visual Novel Character

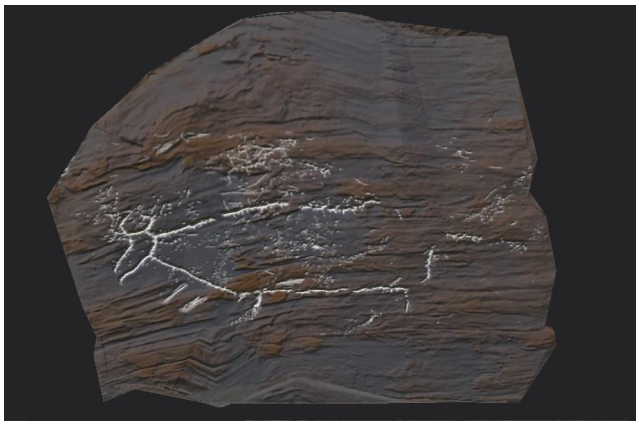

Fig. 5 – Player-made Engraving preserved on game environment

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STEEL, WIRES AND HUMAN FLESH: A SHORT REAL TIME FILM PRODUCTION USING CAD TOOLS

Rafael Bicalho,
rafael.motion.bicalho@gmail.com | Universidade FUMEC, Brasil

Lucas Gonçalves,
lucas.costa@fumec.br | Universidade FUMEC, Brasil

Abstract: Eruption, the short film is about a new experimentation with realities inside a facility, as the computers take on the lead the results are quite unexpected" This is the synopsis of the short film made in real-time inside Marmoset Toolbag.

Keywords: Short Film, Science Fiction, 3D Modelling, CAD

12th International Conference on Videogame Sciences and Arts, 26-28 November 2020, Mirandela, Portugal

Introduction

Eruption is a short film that manifests the collision of realities, the realms of simulation and human life collide in beautiful distortion, and that distortion is what this project is all about, this project is an exploration and visual essay on distortion, glitch effects, pixel sorting, data moshing, all these effects that we left behind and take for granted. The project follows a reconstructive line of thought, to create something and they destroy it only to put it back together again in different ways, just like the cubists that fragmented a subject in many different views and put it all back together, resulting in a painting that appears abstracted.

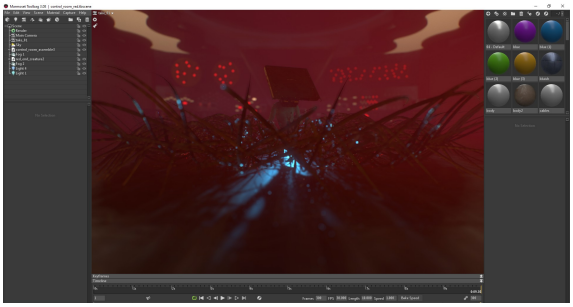

Figure 1: Inside marmoset all in real-time creating of the broken realities scene

Workflow

Eruption is rendered in real-time, which for a production like this, makes everything easier,

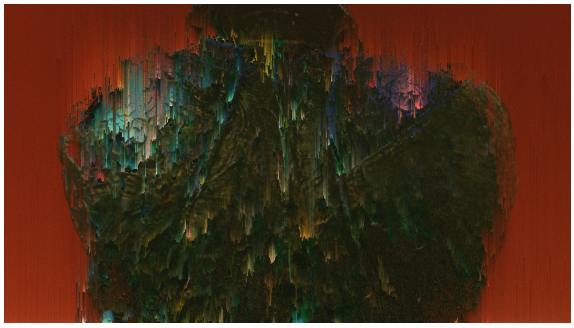

Figure 2: A scene with the effects applied, a technically challenging result. The intent is to make the colors melt in a way that very much resembles, at the same time, a computer glitch and an oil painting.

nowadays you can achieve amazing results with game engines, like the film "Book of the Dead" made by the Unity demo team, making films in real-time is an irresistible way to make films, as by doing so, you facilitate your work tremendously on one of the most fears of any budget, the render times and how much will go to a render-farm facility, it is true that much will change once you switch to a game engine, you suddenly a certain way to create lighting, or to make a simulation, but it is all worth it in the end because of one not so little thing we take for granted when creating budget films, revisions, because if somehow that scene is not fit for the cut, we can just render a new camera angle, or construct another scene entirely and

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put it in the cut, with no issue of waiting on how it will look once it is rendered.

For this project, the pipeline was the following: modeling all the assets in Fusion 360, another cad software, Uving some of them on Ryzom UV, creating materials in Substance Designer, texturing some of the assets in Substance Painter, but also not texturing some of them in Substance Painter, but instead creating a tri-planar projection material in Marmoset, which is where the project takes place, wich a triplanar material, no real UVs are required, with that I can texture some of the assets that do not really need so much detailing really quickly.

Results

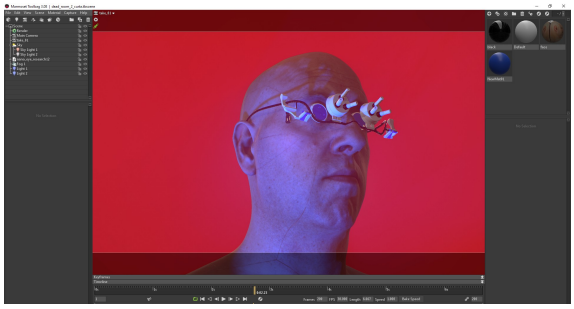

Figure 4: Inside Marmoset creating a scene of the scientist.

Figure 3: A scene with one of the simulation computers, the very first entity you encounter during the film.

Figure 4: Mannequins hanging from the ceiling.

Figure 5: Character before the effects shown on fig. 1

The short film, as well as a more detailed presentation, is available at the following link:

https://www.behance.net/gallery/103453261/ERUPTION

Figure 5: QR Code to watch ERUPTION on Vimeo

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NAMELESS & USTRÁFIKA: HARDSURFACE CHARACTER MODELING FOR VIDEOGAMES USING CAD TOOLS

Rafael Bicalho,
rafael.motion.bicalho@gmail.com |
Universidade FUMEC, Brasil

Lucas Gonçalves,
lucas.costa@fumec.br | Universidade FUMEC, Brasil

Abstract: This poster elaborates on the creative process and production of two 3D characters and their respective sample scenes, made for real time rendering, specifically for video games. The main difference in this design and modelling workflow is the utilisation of CAD-style tools for the character models. Such tools may provide flexibility, ease of use and a low polygon count, which make them ideal for a real time rendering pipeline, and works exceptionally well for hard-surface characters, like the ones shown in this work.

Keywords: Character creation, Hard surface modeling, concept art.

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Introduction

The work of designing and developing a character is central to the narrative experience.

In this work, a viable alternative for the modelling and finishing of characters in the hard-surface style is proposed and exemplified, starting from tools that normally are not integral to the game development pipeline.

With these characters, we intend to show the efficiency and potential of using CAD tools to model characters to render in real time. Such tools provide a plethora of advantages that could be used to make the process of creating characters for games more efficient in certain contexts..

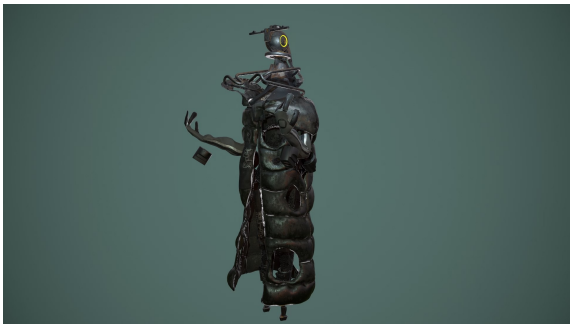

Figure 2: Final real time render of Nameless

Methodology and Workflow

The tool used to model most parts of the characters was MOI3D(Moment of Inspiration), which is a very simple yet effective piece of software, in general, the whole purpose of this unusual workflow is to achieve maximum speed

Figure 2: Final real time render of Ustráfika

when creating characters, and that is why MOI was chosen, as it is a CAD modeling software you do not have to deal with polygons directly, but rather model your objects with Boolean operations, which comes in handy when the goal is to create something complex as fast as possible, the possibilities are endless. MOI also has a very unique tool when exporting, which allows the user to define how many polygons the model is going to have once the objects are converted to .fbx or .obj formats, with the help of this algorithm it is possible to get a low-poly version of the model without the need for retopology.

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Figure 3: Details on Ustráfika's body, made using MOI 3D. A CAD modelling tool

The modeling process used was divided in a couple of software, but that way speeds up the workflow in general, after a quick concept of the characters, the process starts in MOI modeling the whole characters and exporting both a low-poly version without any bevels on and a high poly version of the software. The clothes were done in Marvelous Designer, which also has an algorithm for low poly count quad-meshes. After this the files are imported on a general 3D tool for a topology check, in this example, the software used was Cinema4D, after that the model is UVed in RizomUV, which has an algorithm to UV hard surfaces objects, cutting the lines that are on a 90º angle, then the model is ready for texturing and importing on Unreal Engine 4.

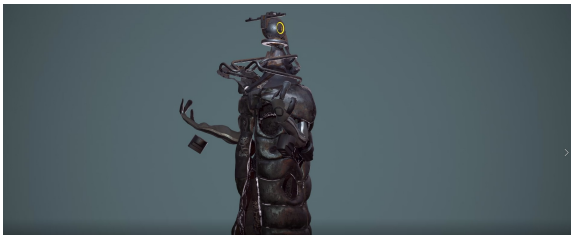

Figure 4: Close-up of the Nameless. The clothes were done using Marvellous Designer

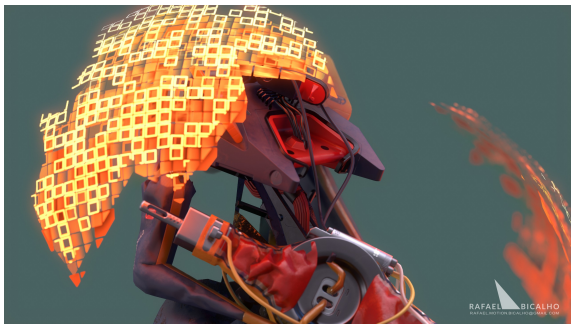

Figure 5: Details on Ustráfika's body, made using MOI 3D. A CAD modelling tool

Figure 6: Close-up of the Nameless. The clothes were done using Marvellous Designer

The character can be seen on the following links, captured directly from Unreal Engine 4:

https://vimeo.com/377850831

https://vimeo.com/374150674

A more thorough documentation is available at:

https://bit.ly/3mbVpdb

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VIDEOJOGOS 2020
12 th INTERNATIONAL CONFERENCE
on VIDEOGAME SCIENCES and ARTS

THE BEAR'S SUFFERING

Gabriel Dias Maia,
gabriel_diasmaia@hotmail.com|
FUMEC University , Brazil

Magda Rezende de Oliveira,
magdar@fumec.br| FUMEC
University , Brazil

Abstract: This work was created with the aim of studying the entire workflow of a Character Artist for games. This requires a complete understanding of all steps to create an attractive 3D model using the industry's most current software and workflow. Starting from the creation of the High Poly model, and its entire process up to the Low Poly game model.

Keywords: Character Artist, 3D model, Software, Workflow.

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Introduction

Electronic games have become a prominent feature among various entertainment platforms. This fact can be largely justified by the technological evolution of tools for creating worlds, characters and new modes of interaction that overcome the limitations presented in the past. Therefore, the idea of the work was to develop the entire process of creating a character for games, from the elaboration of the idea to the final product, mixing the digital sculpture and the study of classical paintings and sculptures(Image 1).

Methodology

The project focuses on demonstrating the areas of the process of creating a 3D character for next generation games, seeking to develop and evolve artistic knowledge, mastery over anatomy and other principles, such as form, color, flow and observation.

Therefore, some softwares and tools were used for different parts of the process. For the sculpture, Zbrush was used, retopology and UVs were made in Autodesk Maya. Substance Painter was used to create the textures and give color to the character and, finally, to present the final result, the Marmoset Toolbag software was used, with the maps and textures created in the previous programs.

Workflow

The Character Artist has a responsibility to fully understand the character art pipeline, including high/low poly modeling, baking theory, texturing, topology theory and workflow optimization.

The first part is the sculpture (High Poly - Images 2 and 3), where the whole character is created, but its density of polygons is very heavy, so the next step is to transform this density into a simple mesh (Low Poly – Image 4) that can run in any console, in this way, the process of retopology and UVs starts(Images 4 and 5), after this process the next step is to design the details of the High model for Low (Baking- Image 6), then apply textures and colors to the character (Texturing- Image 7) and finally presents it or insert it into an engine, for presentation(Image 8).

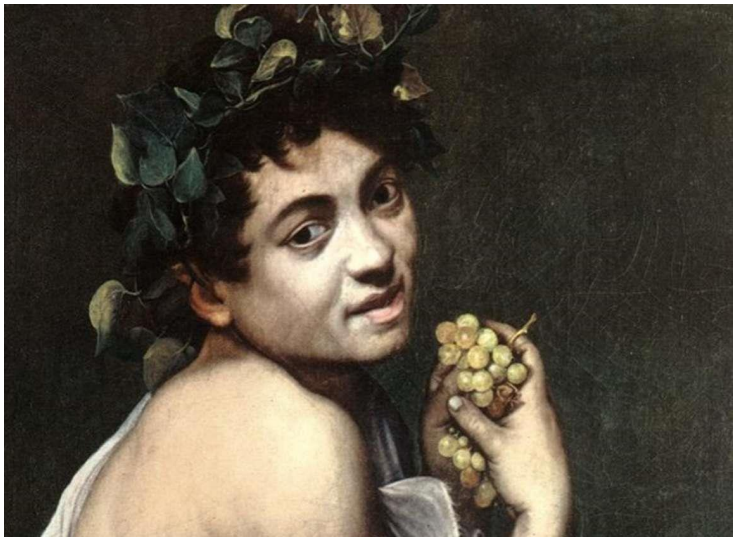

Image 1- Classical painting(CARAVAGGIO).

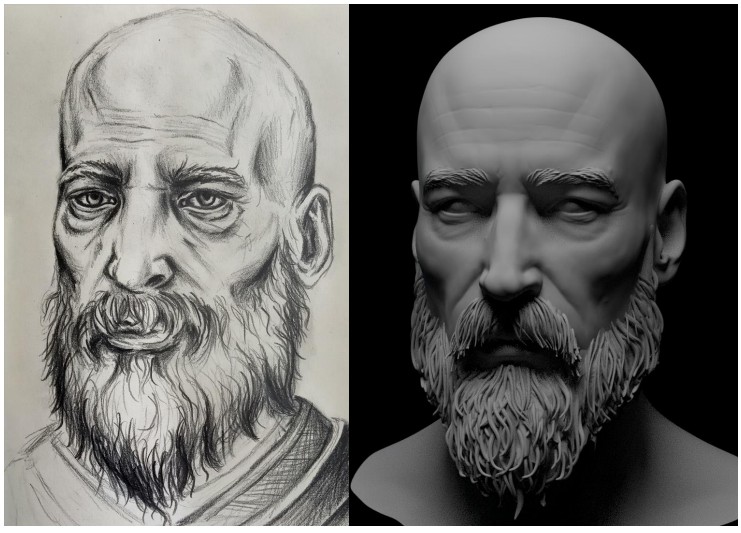

Image 2- 2D AND 3D Concepts.

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SPC videojogos
ipb INSTITUTO POLITÉCNICO DE BRAGANÇA
Escola Superior de Comunicação, Administração e Turismo

Image 3 – High Poly.

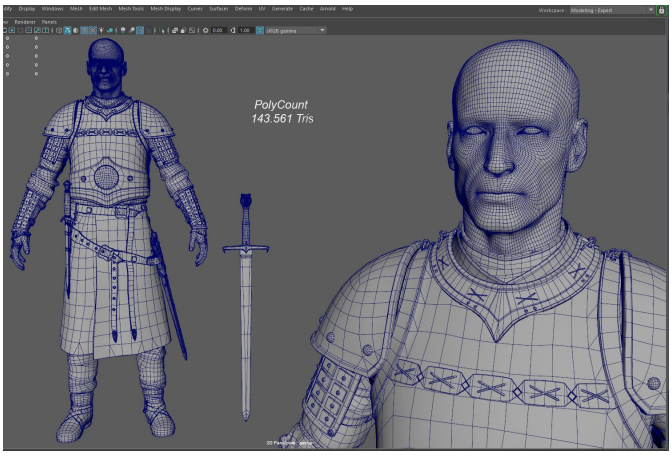

Image 4 – Low Poly.

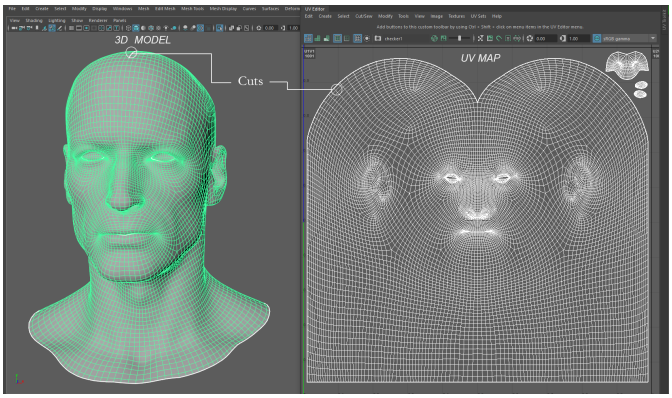

Image 5 – UV Map.

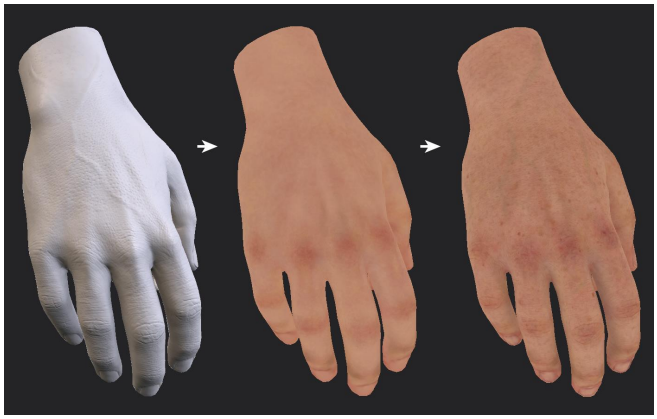

Image 6 – Hand Bake and Texturing.

Image 7 – Head final Texture.

Image 8 – Final Result in Marmoset.

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Presentation link

https://drive.google.com/file/d/1AlYSYJYDwujV3WroXeUZAO3pBkHpCxGr/view

PAPERS

Character Progression for Asymmetric Play

Abel Neto[1][0000-0002-3684-8615], Pedro Cardoso[2][0000-0001-8546-4194], and Miguel Carvalhais[3][0000-0002-4880-2542]

[1] abelneto@live.com
[2] pcardoso@fba.up.pt
[3] mcarvalhais@fba.up.pt

[1] Faculty of Engineering of the University of Porto,
Rua Dr. Roberto Frias, 4200-465 Porto, Portugal

[2] Lusófona University, HEI-Lab: Digital Human-environment Interaction Lab,
Campo Grande 376, 1749-024 Lisbon, Portugal

[2, 3] Faculty of Fine Arts of the University of Porto
Av. Rodrigues de Freitas, 265, 4049–021 Porto, Portugal

[3] i2ADS – Research Institute of Art, Design and Society,
Avenida Rodrigues de Freitas, 265, 4049-021 Porto, Portugal

Abstract. Character progression is a common feature in games. While its origins date back to tabletop role-playing games such as *Dungeons and Dragons* (1974), this is now a feature implemented across diverse game genres. This is widely attributed to the fact that character progression raises engagement, as players build up their commitment to their characters while making strategic choices of how to improve them. In this study, we propose that character progression is also a tool for increasing asymmetry in the different players' experiences through the game. The use of character progression as a tool to generate asymmetry may bring advantages and pitfalls related to asymmetric gameplay. As such, it is important to analyze how character progression can be used to create asymmetric player experiences. This work offers a deconstruction and analysis of current systems of character progression and how they generate asymmetry. This work can be useful for game designers in the discussion and development of systems of progression that reap the benefits of asymmetry while avoiding its risks.

Keywords: Video Games, Character Progression, Asymmetric Gameplay, Game Design.

1 Introduction

Character progression is a feature of games that dates back to tabletop role-playing games (RPGs), such as *Dungeons and Dragons* (1974), also known as *D&D*. Currently,

it is used across multiple genres, from first-person shooters[1] to action-adventure games.[2] Systems of character progression often offer the player some degree of agency as to how to advance their character. We believe that, as players develop their characters in different ways, they start engaging in distinct experiences. These dissimilarities in player experiences are characteristic of asymmetric play, a feature in games in which players play under different rulesets [1].

We posit that character progression can be a powerful tool to generate asymmetry in games. As such, it is important to analyze character progression under the scope of asymmetric play, and to explore the advantages and potential problems that may arise from asymmetry generated by character progression.

We begin by defining what character progression is, and how it is used in games. Then we define asymmetric gameplay, as well as the advantages and challenges it entails within the context of character progression. Finally, we discuss different paradigms of progression and how they generate asymmetry.

2 What is character progression?

2.1 Definitions of progression

We have been able to find several definitions of character progression, each emphasizing different aspects about character growth. We will discuss some of these definitions, as well as propose our own, which we use within the context of this study.

Tavares's definition is as follows:

> If for multiple runs of the game an ongoing change of . . . parameters causes an increasing frequency of win end-states (*wes* for short), then, we call this change in the parameters progression (if a decreasing *freq* of *wes* instead we would naturally consider as a regression). (...) if the parameter change is solely on the character's child parameters, then, let us designate it as character progression. [2]

We believe this definition to be very dependent on whether or not the changes to the character result in an increase or decrease in the frequency of win end-states. We find that changes that don't result in changes in the frequency of win end-states can still be considered progression. Furthermore, we find the dichotomy of progression vs. regression to be very unstable, as it may depend on what the player's goals are within the

[1] An example of this is *Borderlands* (2009), in which players may develop their characters through a skill tree and acquire better equipment as the game progresses.

[2] In *Hybrid Heaven* (1999), the player controls a character that gains access to new actions as they defeat enemies and gain experience points. In addition, different parts of the character's body evolve as they are used. For instance, if the character relies on kicks rather than punches, their legs will grow stronger over time, empowering those attacks.

context of the game. For instance, a player that is engaging in *speedrunning*[3] could value the character's movement speed above anything else. Thus, any decrease in this specific parameter, even if compensated by a substantial increase in others, would, in this case, constitute regression. For this reason, we will avoid this dichotomy, and group both positive and negative changes to the character under the term *progression*.

Zagal and Altizer define systems of character progression as "rules and game mechanisms that articulate or define how the player's characters improve from one game session to the next" [4]. This definition implies that progression relates only to improvements to the characters, while we would prefer to consider all changes to the characters as progression.

House proposes that "character progression (...) is the advancement method of changes that influence character through gameplay" [5]. While we agree that this definition is useful, we find it a bit vague and would like to expand upon it, being more specific in describing the ways character progression occurs in games.

Thus, the definition we will be using is as follows:

> Character progression refers to the development of a character's set of abilities and parameters that affect how they interact with the game world and the remaining characters.

Here, the term *abilities* refers to the set of possible actions that the character can perform, while the term *parameters* refers to the set of values that affect the abilities that can be performed by the character.

2.2 Uses of character progression

Progression systems can be used to give the player a sense that the character they are controlling is developing over time. Adams posits that role-playing games (RPGs), which make use of progression systems can foster a "sense of growing from an ordinary person into a superhero with amazing powers" [1]. While other genres usually provide players with these powers from the start of the game, RPGs allow players to earn them through completion of in-game objectives, while also giving them the choice of which abilities to develop further [1].

Dungeons and Dragons (1974) was the first major game to feature character progression, under the form of experience points and leveling up. Peterson described progression to be *D&D*'s object of play [6]. While the different scenarios the players encounter have their own internal objectives, "the overarching reward for play is unending self-improvement" (ibid.). Ewalt argues that due to this character growth, "playing the game becomes a uniquely visceral experience" [7].

As for massively multiplayer online role-playing games (MMORPGs), Ducheneaut et al. state that "players build up their commitment to the game as the level of their character increases" [8]. As with traditional RPGs, character advancement is a primary

[3] *Speedrunning* is the process of completing a game as quickly as possible without the use of cheats or cheat devices [3]

motivational factor [9]. This may be due to the Zeĭgarnik effect, which relates to the fact that when actions are interrupted or not completed, people are more motivated to finish them [10]. In addition to this, the closer someone is to their goal, the more motivated they become, which is known as the "goal gradient effect" [11]. In other words, a player that is close to unlocking a new ability for their character may be more motivated to continue working towards it.

In addition to these psychological reasons that may explain what makes games with character progression engaging, Zagal and Altizer posit that there may also be social and emotional reasons as well [4]. These reasons could include a "nurturing effect", in which the player starts to care about their characters and their growth, developing curiosity and expectations that are related to abilities she'll gain access to in the future [4].

Systems of progression can also be useful from a game design standpoint. For instance, it may facilitate the task of learning how to play the game by gating mechanics and systems behind a progression curve [12]. By restricting the player's access to advanced mechanics until they get acquainted with the basics, lowers the risk of making them feel overwhelmed [12].

3 Asymmetric Gameplay

Symmetry in gameplay refers to the similarities or differences in roles played by different players in a given game [13]. According to Adams, in a symmetric game, all the players strive towards achieving the same victory condition, playing by the same set of rules [1]. An example of this is basketball, in which the initial conditions, actions allowed, and the victory condition are the same for both teams [13].

Adams defines asymmetric gameplay as characteristic of games in which different players may play by different sets of rules while having different victory conditions [1]. We amend this definition of asymmetric games by claiming that the victory condition can also be the same for both sides. An example of this is *Keep Talking and Nobody Explodes* (2015), an asymmetric game in which two players cooperate in order to defuse a bomb, sharing the same victory condition.

According to Shafer, replayability increases with the number of new experiences a game can provide to players [14]. Characters with distinct abilities and roles provide variety, which fosters replayability. He adds that asymmetry can also improve strategic decisions: if all sides play the same way in a game, the optimal strategic response will always be the same in identical situations. Asymmetry can be used to avoid problems like this.

Adams states that "symmetry is the simplest way of making a game fair, but it tends to emphasize the artificial nature of the contest. Games are often more interesting, and feel more 'real', when they contain asymmetries" [15].

Snyder states that asymmetric gameplay offers unique perspectives and experiences for each player [16]. He states that symmetrical multiplayer only provides one point of view to the players, while asymmetry allows them to see all sides of any game.

As such, asymmetry can be a valuable tool to increase the longevity of a game and give the players a variety of different experiences within the same game.

3.1 Challenges of asymmetric play

Burgun identified a number of problems related to asymmetric play [17]. Next, we discuss each, applying those criticisms to the asymmetry generated by character progression. By doing this, we were able to examine which of these pitfalls are prone to be inherited by games that feature character progression.

Challenge 1
"It forces the player to 'play designer.'"

Burgun shows concern related to the fact that in multiplayer games with different factions or characters, the player is faced with the choice of picking one. This is a "non-strategic choice that has strategic ramifications" that the player may not be aware of. For the sake of this study, we can think of this challenge as being related not to the choice of a character or faction – as in some games all players start with a blank-slate character, e.g. *Runescape* (2001) –, but to a choice the player makes while progressing her character. Although these choices are strategic by nature, the player may not be fully aware of the repercussions of her choices.

Dark Souls (2011) has a system of soft and hard caps at play when it comes to the attributes a player gains upon leveling up their different stats [18]. If a player chooses to level up their Strength stat past level 20, they will begin to receive diminishing returns from that investment. If they level it up past level 40, that investment is effectively wasted, since the character stops improving once you cross the hard cap threshold. These soft and hard caps can be deduced, but are not an explicit mechanic at play, nor are they explained to the player at any point. Since stats can be improved up to level 99, players can be artificially raising their character level without getting any benefit from it. Furthermore, players can engage in competition by invading other player's game worlds. The game matches players with characters of similar levels. This creates the potential for players with the same level to be competing despite one having remarkably higher attributes than the other.

Challenge 2
"It tends to cause games to be vastly less elegant than they otherwise could be."

Burgun points out that "[i]f you make a fighting game with just 4 characters, what you've actually done is create ten different games. Each matchup is a distinct game." He claims that this amount of content may cause new players to feel intimidated, as there is too much to learn about the game [17].

This statement is in opposition to one of the benefits of asymmetry: replayability. While games with complex systems that depend on player choice can take a long time

to learn, those choices can be delivered over time to the player in manageable quantities, resulting in stimulating challenges.

In *Path of Exile* (2013), players manage their character's progression through a skill tree that features 1.325 different nodes players can choose from. As they progress through the game, players receive skill points upon levelling up, as well as a reward for completing certain quests. While the skill tree may look complex at a first glance, players often progress node by node, which greatly reduces the number of options to choose from at any given point in the progression. More dedicated players often feel compelled to engage in *theorycrafting* – the discovery of rules that cannot be determined through play [19]–, analyzing different potential routes through the skill tree in order to determine the best. This creates a reason for players to come back to the game time after time and experiment with different strategies.

Fig. 1. A small section of the Passive Skill Tree in *Path of Exile* (2013).

Challenge 3
"It generally causes games to be vastly harder to balance than they should be."

Here, Burgun expresses his concern with the fact that the addition of asymmetric elements to a game causes it to be considerably harder to balance. He also states that modern asymmetric games can no longer strive for real balance. Instead, they aim for an "acceptable tier-list", in which there aren't any options that are so powerful that it feels unfair to use them nor any options so underwhelming that they are rarely chosen by players [13]. We find this to be a valid concern since it is undeniable that adding more options brings about the need to balance each of them.

Challenge 4.
"It constrains dynamics."

Here, the author states that due to the fact that the players aren't starting from a completely "blank slate", and instead begin with a faction or character with predefined traits, the game dynamics cease to be emergent, or are constrained. We find that this criticism cannot be applied towards asymmetry generated by character progression

since, as we have previously pointed out, there are examples of games with character progression that make players begin from the same blank-slate state.

Challenge 5
"It's a smokescreen, making it harder for designers to really judge the quality of their system, which results in worse systems."

Burgun states a large roster of characters or factions can make a somewhat dull system seem more interesting, which makes it difficult for game designers to correctly analyze the game and find elements that aren't working as intended. We can apply the same criticism towards the large number of possible character progression options some games allow for. In games with asymmetric character progression and roles, a major concern will always be to keep every role as equally interesting as possible for the players, especially in games that require all roles to be played [13].

4 Paradigms of character progression and their contribution to asymmetric play

In this section, we discuss the different paradigms of character progression we were able to find and the way they generate asymmetry in games. To do so, we selected a number of games that feature character progression and examined how their systems improve the players' characters and generate asymmetry. As our categories consolidated, we used them to classify the mechanics of character progression in the sample of selected games. When a given mechanic didn't fit our classification, we reviewed the categories with the goal of making them able to describe the different paradigms of progression. Through this process, we were able to distinguish between two major categories of progression, *effective* and *potential* progression.

4.1 Effective Progression

Effective progression refers to changes to the character that directly affect their actions within the game. Either through changes in their attributes, or the addition or removal of different abilities in their toolset, effective progression makes a character better or worse at specific tasks. This leads to players adopting different strategies, which increase the asymmetry in the different character's affordances.

In multiplayer games, players often face challenges that require a diverse set of affordances in order to be surpassed. Current progression systems usually incentivize — or in some cases, require — players to improve their characters in a limited set of abilities, instead of allowing their characters to perform every possible action in the game. An example of this is *Payday 2* (2013), in which up to four players perform heists, competing against the game system. Each player controls one character that can progress through five distinct skill trees (*Mastermind*, *Enforcer*, *Technician*, *Ghost*, and

Fugitive), getting access to traits that improve their affordances in different ways. For instance, a character that specialized in the *Enforcer* skill tree may be able to place more ammo bags in the game world for their allies to replenish their ammunition, while a character specialized in *Mastermind* may be better equipped to keep hostages under control allowing the rest of the team to be available to perform other actions. This creates the opportunity for different characters to complement each other's strengths and collaborate.

Additionally, as we mentioned in section 3, asymmetry may enhance strategic decisions even in games in which players compete against one another [14], as well as offer unique perspectives and experiences for each player [16]. Therefore, we posit that effective progression, due to it leading to an increase in asymmetry, inherits those same advantages.

Attribute changes

This paradigm of progression relates to the changes to the numeric parameters that affect the way the character interacts with the game world. This is sometimes described as vertical progression [20]. In most RPGs, these parameters are usually linked to the character's ability to deal and withstand damage but can also affect the outcome of non-combat activities, such as persuading non-player characters (NPCs) or lockpicking doors.

Changes to these attributes make different characters better or worse at specific tasks in a very linear way. High attributes are usually indicative of a character's strengths, while low attributes make up its weaknesses. Players often begin the game as a blank slate and must choose which attributes they want to cultivate or neglect as the game progresses.

Fig. 2. *Final Fantasy VII* (1997) status menu. The character's *Health Points* and *Magic Points* as well as their attributes (on the left side), can be considered parameters which are scaled as the game progresses.

Attribute changes may be attained in different ways. In RPGs, gaining a level often permanently increases a character's attributes. Some games allow the player to choose which attributes to improve, while others have characters whose attributes increase in

a predetermined way. Another way to increase a character's attributes is by acquiring (and usually equipping) different items in the game. As such, players may choose to follow different strategies when deciding which items to equip in order to overcome the game's challenges.

Fig. 3. *Final Fantasy VI Advance* (1994) equipment menu. When equipped, different weapons affect the character's attributes (right-hand side) in different ways.

Toolset changes

Another paradigm of progression relates to the addition or removal of actions the character can perform. This can happen by gaining or losing items or abilities that unlock said actions. This can be described as horizontal progression and relates to the addition or removal of tools suited for specific situations, as opposed to the "brute force" manner in which vertical progression systems advance the character's capabilities [21]. The abilities and tools the character acquires may bolster its current affordances, as well as equip him with new ones.

For example, in *Legend of Zelda: Breath of the Wild* (2017), the player unlocks a paraglider that allows her to leave the starting area by making it possible to safely descend from the cliffs that surround it. This can be seen as a toolset change that allows the player to overcome a challenge that she would not have been able to without access to that tool. In this game players may also discover new weapons each with a particular damage value and set of attack animations. This is an example of a tool that bolsters a preexisting ability of the character: that of damaging enemies in combat.

These differences in what actions a character can and cannot engage in are very common in asymmetric games. As players are unable to perform certain tasks, they may rely on another player to do them, engaging in cooperation with one another.

An example of this are the talent trees in *World of Warcraft* (2004). Characters acquire a finite number of talent points as they level up, which they can then spend on unlocking different talents in their class's talent trees. Active and passive talents were arranged in three separate 'trees', with access to progressively higher tiers of talents granted by spending sufficient talent points in that tree [22].

A player of the Shaman class chooses how much they wish to invest in each of the three of their class's talent trees: *Elemental*, *Enhancement*, and *Restoration*. In the event that they choose to invest most of their points in *Restoration*, their healing spells will be more efficient, and new healing spells will be unlocked. As such, this character

would be better equipped to perform the task of being a healer and would be sought after by groups looking for someone to fulfill that role. Typically, there are three roles to be filled in a party (*healer*, *tank*, and *damage-dealer*), each of which offer a different experience for the player and require a different investment strategy in the talent tree.

Toolset changes may occur as a character levels up and unlocks different abilities, or as players acquire items that allow them to act in new ways. In some cases, players incur toolset changes simply by progressing through the game. For example, in *Dragon Quest XI: Echoes of an Elusive Age* (2017), *Zoom* is a spell that lets you revisit any location you've already been to. You obtain the spell not by levelling up, but by progressing through the game until a certain point, at which one of the party members teaches the main character the spell.

As we established, the gating of these toolset changes behind a progression curve can be useful from a game design standpoint, as it reduces the risk of a player feeling overwhelmed while learning how to play the game [12]. In games that feature asymmetry, this may also function as a way of progressively showing the player how characters that underwent a different progression path act in the game world. For instance, in multiplayer games where the world is sectioned into areas with challenges meant for characters within a certain progression state (commonly referred to as a level range), players will mostly observe and interact with characters with a toolset as extensive and complex as their own character's. This is very common in MMORPGs, in which a new character's progression and their traversal through the game map often go hand in hand. As a player levels up their character in order to be able to travel to a location with harder enemies, they get a chance to interact with other players' characters and progressively learn how those characters act in the game world.

4.2 Potential progression

Potential progression refers to character progression that allows the player to attain effective progression without directly affecting how the playable character acts in the game world. This includes in-game currencies, experience points, and reputation the player accrues, increasing her potential for progression, or social status in the game world.

In-game currencies gathered through completing the game's objectives can usually be spent in order to acquire attribute or toolset changes in the form of items or pieces of equipment that grant those changes. In the same fashion, experience points (XP) are often accumulated during the player's traversal through the game.[4] Upon reaching a certain threshold, the character levels up and is either rewarded with immediate effective progression, or another form of currency (commonly called *Skill Points*) that the player can spend to improve her character in the way she chooses. This allows for a higher degree of asymmetry to occur, as different players adopt different strategies as to how to spend their in-game currency.

[4] For some games, the player accrues a single currency that can be used both as XP and as a payment to purchase items. This is the case with *Dark Souls* (2011) in which players earn *souls* by defeating enemies and can later spend them at merchants or to level up their character.

Some games allow players to *respec*[5] their spent skill points. In *The Witcher 3: The Wild Hunt* (2015), players may purchase a *Potion of Clearance* from a vendor. By drinking it all of their character's spent skill points become available once again, and their skill tree is reset. Mechanics such as these allow players to adopt a different strategy while developing their character without having to restart from the beginning.

It is also worth noting that not all games track character growth over a single experience points parameter. That is to say, some game characters have different skills that players can develop by practicing them, each with an experience points (XP) parameter. In *The Elder Scrolls V: Skyrim* (2011), players can develop a total of 18 different skills by performing actions related to them. For example, a player may raise his *Smithing* skill by forging equipment, or their *Block* skill by blocking enemy attacks with a shield. This differs from the traditional approach of a single XP parameters, as in this case, players raise their character's proficiency in a particular skill by performing it repeatedly. As such, the character becomes proficient at the roles the player chooses to perform in the game. Multiplayer games that utilize this type of approach may allow players to tailor their character to be good at the roles they themselves enjoy performing. This may create asymmetric experiences in which players gravitate towards different roles and end up with characters that are significantly different from one another.

Another form of potential progression at play in some games is reputation. The player may accrue reputation for a faction, which while it usually doesn't directly improve their character, it may open up new options for character development. In *World of Warcraft* (2004), a player cannot purchase some items from certain vendors until they increase their reputation towards the vendor's faction. In order to do so, they must complete quests for that faction, or defeat the faction's opponents.

Fig. 4. In *World of Warcraft* (2004), there are a number of factions for which the player can increase or decrease her reputation. Positive reputation results in advantages such as in-game shop discounts from that particular faction. However, negative reputation can make members of said faction attack the player on sight.

[5] A term largely used to refer to the action of rebuilding a character's ability set, often by redistributing the skill points that were previously allocated.

Reputation systems such as this can potentially be used to increase asymmetry in games. As players choose to side with different factions, they could get access to different character growth options which may foster different playstyles and experiences.

5 Conclusions and Future Work

We have examined how character progression is commonly used, as well as how it can generate asymmetry in play. We established that character progression can be effective or potential, depending on how directly it affects a character's affordances. As players make choices that result in their characters progressing in different ways, games become more asymmetric. This asymmetry brings not only advantages, but also potential pitfalls. If we are to reap the benefits of creating engaging progression systems, such as the increase in replayability and the improvement of the strategic decisions the players are performing, game designers must be aware of the problems associated with asymmetry. Only then can they be equipped to design ways to mitigate — or perhaps even solve — those problems. We believe some of the potential pitfalls of asymmetric play can be addressed during the pre-production stage of game development, where solutions can be devised, for instance, to reduce the burden of knowledge on new players by slowly exposing them to new mechanics. However, problems such as the difficulty of balancing asymmetric games will require a greater investment in the testing stage of a game's development. In fact, even during the production stage, the game designers will likely need to be constantly iterating on the progression system, determining how different characters are allowed to interact with one another and the game world, with the ultimate goal of striking an acceptable level of balance in regard to the viability of the different progression choices.

The scarcity of studies regarding character progression prompted us to define our two paradigms of progression. These categories were based on a number of case studies that were mostly comprised of RPG games. By expanding our analysis to other genres, we may potentially uncover new and interesting paradigms, or even new subdivisions of our current ones.

This may also be the start of a framework of asymmetric play that describes how asymmetry can be generated and used in games. This would further the knowledge on Game Design about asymmetric gameplay systems and the ways these affect players' agency in the game world. Furthermore, we could establish game design principles for the development of games that support interconnected and diversified player roles and explore new dynamics of player interaction.

Furthermore, we believe it is important to continue exploring how specific progression systems create asymmetry in players' experiences. For instance, it would be interesting to study how asymmetry emerges in systems with single XP parameters, as opposed to systems of multiple XP parameters. In systems of multiple XP parameters, the player's actions within the game could become a more direct reflection of how her character will improve. As players develop an interest and actively engage in certain tasks, they will become more proficient at them, relying on other players to complement their weaknesses, in a social dynamic akin to that of our society. Games that fostered

this type of interaction could be used to address social issues and potentially be used as tools for the creation of empathy. For instance, progression systems could be designed in a way that presents different players with more, less, or simply different progression choices. This could act as the base for a game featuring an emergent narrative that focuses on the themes of economic mobility, racial discrimination, or gender inequality. By analyzing and expanding on these systems, we could help game designers create games that utilize progression systems in ways that make players view their characters as a unique product of the choices they made within the game. We believe this could greatly increase the player's narrative immersion[6] and act as a tool for the creation of meaningful multiplayer interactions and experiences that deliver powerful messages regarding the aforementioned social issues.

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Procedural Game Level Generation by Joining Geometry with Hand-Placed Connectors*

Rafael C. e Silva[1], Nuno Fachada[1,2], Nélio Códices[2,1], and Diogo de Andrade[1]

[1] Lusófona University, Campo Grande, 376, Lisbon, Portugal
castroesilva.rafael@gmail.com,
{nuno.fachada,nelio.codices,diogo.andrade}@ulusofona.pt
[2] Instituto Superior Técnico, Av. Rovisco Pais, 1, Lisbon, Portugal

Abstract. We present a method for procedural generation of 3D levels based on a system of connectors with pins and human-made pieces of geometry. The method avoids size limitations and layout constraints, while offering the level designer a high degree of control over the generated maps. The proposed approach was originally developed for and tested on a multiplayer shooter game, nonetheless being sufficiently general to be useful for other types of game, as demonstrated by a number of additional experiments. The method can be used as both a level design and level creation tool, opening the door for quality map creation in a fraction of the time of a fully human-based approach.

Keywords: Procedural content generation · Video games · 3D levels · Gridless generation · Mixed-initiative content creation

1 Introduction

In this paper we describe a method for procedural generation of 3D levels for video games. The proposed method uses a system of connectors with pins, similar in concept with a jigsaw piece or an electrical plug and outlet, to connect pieces of pre-made geometry for generating levels. This approach allows the level designer to avoid size limitations and layout constraints, such as in the case of grid-based layouts, while offering full control on the design of individual geometry components, including the placement and customization of associated connectors, using the chosen game engine's visual editor. Additionally, the generation algorithm is highly customizable, with several parameters for a designer to tinker with and control the properties and layout of the final level. This technique follows a mixed-initiative methodology, where both human and computer are actively involved in the level design process [8]. As such, while the levels are procedurally generated, the method still offers a degree of control to the level designer.

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The proposed procedural content generation (PCG) method was initially developed for *Trinity*, a multiplayer third person shooter [13], developed as a semester project at Lusófona University's Bachelor in Videogames [5]. Given the frenetic and fast paced nature of the game, in which players have multiple options for mobility, the main goal was for the generated levels to encourage this type of gameplay, facilitating navigational flow.

The paper is organized as follows. In Section 2, we review related work concerning the use of PCG for level design, with special focus on the inspirations and references that lead to the core idea of our approach. In Section 3, we describe the proposed technique, namely the components that make up the system and the details of the PCG algorithm. Several case studies are presented in Section 4, including one where the method was used for generating levels for the *Trinity* videogame. Section 5 closes the paper, discussing potential improvements and offering some conclusions.

2 Background

Mixed-initiative content creation (MICC) [8], in which a mix of human input and computer-assisted PCG are used for game design, is a promising area in game development in general and level design in particular. Game level design and testing can be notoriously laborsome and time consuming [12], and with cost-effectiveness in mind, a number of level design tools, as well as full games, have been making use of computer-aided approaches. Tanagra is one such tool for 2D platformers [14], allowing human designers to partially specify a level's geometry and pacing, leaving up to the computer to fill in the gaps. Tanagra guarantees that generated levels are playable when human-defined specifications are valid.

Oblige is a MICC level generator for the DOOM family of games [2]. It allows the level designer to set a number of parameters, such as level size and approximate quantities of each type of level section (outdoors, caves, hallways, etc.), each type of monster, and of each type of power-up. Levels are created using shape grammars [10] on a grid-based layout, and are limited to a single floor – an inherent limitation of the DOOM family of games.

In the context of FPSEvolver, a Counter-Strike-like videogame, Ølsted et al. [11] proposed a novel grid-based interactive evolution approach for generating multiplayer maps according to the players' preferences. Players vote on a selection of evolving scenarios, with the goal of generating levels in accordance with what they consider to be a good map.

Looking at comercial games, roguelikes such as *Spelunky Classic* [17], *The Binding of Isaac: Rebirth* [9] and *Enter the Gungeon* [4] all use MICC. *Spelunky*, for example, uses premade room templates to fill out a grid. Rooms with specific characteristics such as top entrances and bottom pits are considered when generating levels in order to create a valid path for the player to traverse to the end [18,7].

The Binding of Isaac: Rebirth [9] (*Isaac*) uses MICC to create its map by connecting several rooms together [6,15]. These rooms are fit into a grid. However, each room may take more than one grid space, and each grid space it occupies can be connected to by other rooms occupying adjacent grid spaces. This allows for big rooms to connect to small rooms and vice-versa. Fig. 1 shows some screenshots of the "minimap" of a level displaying all the rooms discovered.

Fig. 1: Several minimaps of the full layout of a level in *The Binding of Isaac: Rebirth*.

Enter the Gungeon also features MICC, though it does not connect its rooms directly to one another as in *Isaac*, employing a more complex algorithm to obtain the desired layout. This algorithm uses nodes and connectors, placing different pre-made rooms as those nodes and afterwards creating corridors to join the rooms for the final map layout. Not only is the hand of the human designer present in the rooms, it is also visible in the overall layout of the level, as there seems to be a set of predefined general level layouts that make the algorithm place certain rooms in certain orders and block some paths [3].

3 Methods

The proposed approach falls under the MICC methodology, since the level designer controls the type of levels to be created, although these are procedurally generated. The generation process is highly configurable. For our prototype we used the Unity game engine [16] and leveraged its editor tools to handle the input of the human designer.

In broad terms, one or more **connectors** (each containing one or more **pins**) are placed in the geometry of a **level piece**, and then several level pieces are fed into the **generation manager**, composed by a number of generation parameters to be specified by the level designer. The generation manager, containing the level pieces and the generation parameters, then passes this data to the **generation algorithm**, which produces a fully playable map by connecting level pieces according to their connectors and the specified generation parameters. The level generation process is summarized in Fig. 2. Level pieces, connectors and pins

are detailed in Subsection 3.1. The generation manager and the generation parameters are discussed in Subsection 3.2. Finally, the generation algorithm is presented in Subsection 3.3.

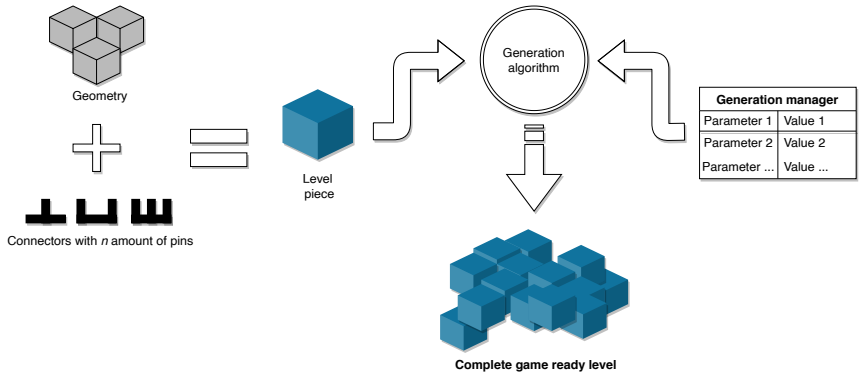
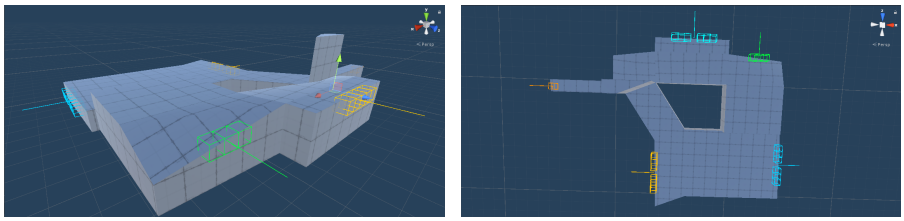


Fig. 2: Summary of the level generation process.

3.1 Level Pieces, Connectors and Pins

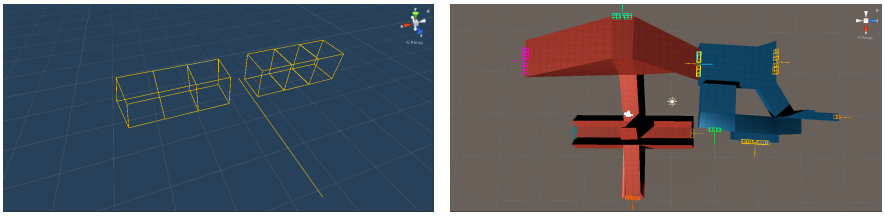
Level pieces are sets of geometry that include one or more connectors and any other elements the level designer wishes to spawn with the piece. These pieces are attached to each other by their connectors during the generation process. In Fig. 3, we see an example of how a level piece looks like in the Unity engine editor, where the connectors are visible. Note that for a piece to be usable by the generation algorithm it needs to have at least one associated connector.

Connectors are the components that determine where two level pieces will join. Each connector has a given number of pins which determine what other connectors it can connect with. The number of pins in a connector is illustrated by colored three-dimensional shapes, as shown in Fig. 4. Connectors are aware of their heading, represented in Fig. 4a by the straight line. Connectors can only form pairs with each other if they have an equal number of pins, as shown in Fig. 4b, or if the pin count difference is within a tolerance parameter set in the generation manager. When two connectors are matched, the piece being evaluated (*tentative piece*) will move so its connector and the connector of the selected placed piece (*guide piece*) are facing each other and at a distance defined by the designer in the generation manager (zero by default, connectors will overlap). Pieces can also overlap, but if any kind of geometry overlapping is undesired, the generation manager provides a clipping correction option to use physics simulation to push the pieces apart, as described in reference [1].



(a) Perspective view. (b) Top-Down view.

Fig. 3: A level piece with its various connectors visible.



(a) Isolated 6-pin connector with its heading represented by the straight line. (b) Two level pieces joined at their compatible connector.

Fig. 4: Connectors and geometry forming level pieces.

3.2 Generation Manager and Generation Parameters

The generator manager is where the designer can define the level piece prototypes to be used in the level, as well as specify the generation parameters, summarized in Table 1.

The `genMethod` parameter is crucial to the algorithm. There are four generation methods which produce different types of map, as shown in Fig. 5. These are as follows:

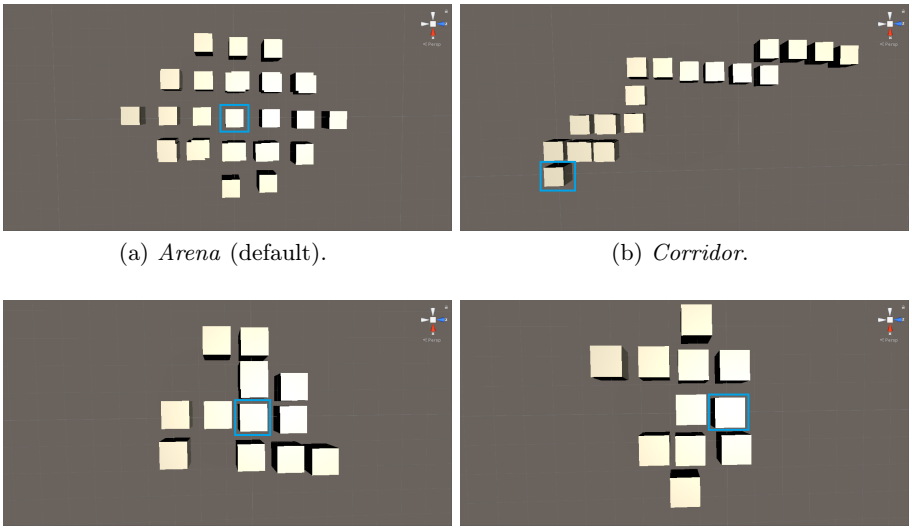
- The *arena* generation method (Fig. 5a) aims to create maps that sprawl in all directions, covering a large area with geometry.
- The *corridor* generation method (Fig. 5b) aims to create long, narrow levels where the geometry seemingly follows a line.
- The *star* generation method (Fig. 5c) is a mix of the arena and corridor generation methods, creating corridors sprawling from the starting piece and ending when that piece has no empty connectors.
- The *branch* generation method (Fig. 5d) creates branches in the same manner as the star method, however it does not return to the starting piece, choosing instead a previously placed piece to start a new branch, repeating this process however many times possible.

Table 1: Generation manager global parameters.

Parameter	Description
`pieceList`	List of level piece prototypes to be used by the generator to create the level.
`useStarter`	Boolean. If `True`, the generator will select the first level piece from the `starterList` instead of the `pieceList`.
`starterList`	List of level piece prototypes to be used as the first level piece if `useStarter` is `True`.
`genMethod`	Selection of generation method. Available options are *arena* (default), *corridor*, *star* and *branch*.
`starterConTol`	The starting piece is selected among the set of pieces with most connectors (*arena* and *star* generation methods) or fewer connectors (*branch* and *corridor* generation methods), $n_{\max}$ or $n_{\min}$, respectively. The `starterConTol` parameter is an integer representing a tolerance, in number of connectors, from the piece(s) with most (or fewer) connectors, allowing pieces with as few as $n_{\max} - n_{\texttt{starterConTol}}$ (or as much as $n_{\min} + n_{\texttt{starterConTol}}$) connectors to be selected as the starting piece.
`maxPieces`	Integer. The maximum number of pieces the generator will place after placing the starting piece.
`pinTolerance`	Integer. The maximum allowed difference between pin counts in two connectors to allow them to be paired up.
`fixClipping`	Boolean. If `True`, the generator will use the available physics system to push overlapping pieces apart. Otherwise allows for overlapping geometry.
`pieceDistance`	Real value. Represents the spacing between two connected connectors. Works independently of `fixClipping`.

Table 2: Specific parameters for the *star* and *branch* generation methods.

Parameters	Description
`branchPieces`	Integer. Defines how many pieces will a branch contain in average.
`branchPiecesVar`	Integer. Represents the maximum variance from `branchPieces` in each branch.
`pieceSkip`	Integer. Defines how many pieces will the algorithm skip ahead from the starting piece when finding a piece to start a new branch. Only valid for the *branch* generation method.
`pieceSkipVar`	Integer. Represents the maximum variance from `pieceSkip` on each skip. Only valid for the *branch* generation method.



(a) *Arena* (default). (b) *Corridor*.

(c) *Star*. (d) *Branch*.

Fig. 5: Example outputs of the level generation methods. The blue square indicates the starting piece.

The different generation methods achieve their aims by guiding how the generation algorithm chooses the **starting piece** and the next **guide piece**, as discussed in the next subsection. Both the *star* and *branch* methods require a few additional parameters, described in Table 2, the purpose of which will become clear in the next subsection.

3.3 Generation Algorithm

The pseudo-code of the generation algorithm is presented in Algorithm 1. Details of how each of the algorithm steps works are given in the next subsections.

Selecting the starting piece The algorithm begins by selecting and placing the starting piece of the level in the game world. The method of selecting this piece depends on the generation method chosen. For the *arena* and *star* generation methods, the piece with most connectors is selected. Conversely, for the *corridor* and *branch* generation methods, the piece with fewer connectors is selected. If there are multiple pieces with the same highest/lowest number of connectors, one of them is picked at random. In any case, if the `useStarter` option is selected then it will override the generation method and instead choose a random piece from `starterList`.

Algorithm 1: Level generation.

```
1  startingPiece ← genMethod.SelectStartingPiece()
2  guidePiece ← startingPiece
3  for i ← 0 to maxPieces do
4      connection ← none
5      do
6          failCount ← 0
7          if i > 0 then
8              guidePiece ← genMethod.SelectGuidePiece()
9          do
10             tentativePiece ← piecesList.GetRandomItem()
11             connList ← guidePiece.GetConnectionsWith(tentativePiece)
12             if connList is not empty then
13                 connection ← connList.GetRandomItem()
14             else
15                 failCount ← failCount + 1
16         while connection is none and failCount < maxFails
17     while connection is none
18     newPiece ← tentativePiece.Clone()
19     guidePiece.Join(newPiece, connection)
```

Selecting the guide piece When the main loop of the algorithm begins, the starting piece is selected as the guide piece. In subsequent iterations, the generation method will influence this selection as follows:

- In the *arena* generation method, the algorithm checks if the current guide piece has unused connectors and if so, keeps it as the guide piece. Otherwise, the piece placed immediately after the current guide piece is selected as the next guide piece.
- In the *corridor* generation method, the guide piece in each iteration is always the most recently placed piece.
- In the *star* generation method, when a new piece is placed, a counter is incremented. Until the counter reaches `branchPieces` ± `branchPiecesVar`, that piece remains the guide piece. When the counter hits the limit, it resets and the starting piece is selected as the guide piece if it still has unused connectors. Generation ends when the starting piece no longer has unused connectors.
- In the *branch* generation method, when a new piece is placed, a counter is incremented. Until the counter reaches `branchPieces` ± `branchPiecesVar`, that piece remains the guide piece. When the counter hits the limit, it resets and, counting from the starting piece, a jump of `piecesSkip`±`piecesSkipVar` pieces is performed. The next guide piece is the piece where the jump "lands".

Selecting and evaluating a tentative piece A tentative piece is randomly selected from `pieceList`. All possible connector pairings between the guide piece and the tentative piece are evaluated. Valid pairings are stored in a temporary list. Then one of these valid pairings is selected at random. A connector pairing is considered valid if, and only if, the following conditions are true:

1. Both connectors are unused, thus available for pairing.
2. The pin counts of both connectors is the same or its difference is equal or less than `pinTolerance`.

Selecting more pieces and moving on If the previous step yielded a valid result, a new piece is created by cloning the tentative piece. The new piece is then placed in its correct position in the game world. If, however, no valid pairing was found in the previous step, the algorithm will keep the same guide piece and randomly select another tentative piece from `pieceList`. This process is repeated until a valid pairing is found or a limit of failed attempts is reached for the current guide piece. This process will continue until there are no more valid pieces or connectors to select in the game world, or the maximum number of pieces has been placed.

4 Case Studies

4.1 *Trinity* – a Third Person Multiplayer Shooter

The proposed PCG algorithm was used to create the levels – arenas – for *Trinity*, a competitive multiplayer game [13]. The competition between players takes the form of shooting projectiles at each other while dashing, jumping and running around the map to dodge incoming enemy projectiles. The game can be seen in Fig. 6.

The PCG approach to level design was chosen since it is our belief that having players learning and adapting to a new map every match would promote the frenetic nature of the game, while boosting its replay value. However, given the game's focus on player vs player, fully AI-controlled design of high quality maps would be difficult to achieve, hence the need for some level of input from human designers, paving the way for a MICC approach.

Trinity was developed with the Unity game engine, which offered a number of important features for the implementation of the proposed PCG algorithm, namely:

- Parameterization of the generation manager was done via the object inspector, as show in Fig. 7.
- The built-in physics engine performed the necessary piece adjustments required when the `fixClipping` parameter is activated.
- The *prefab* system allowed designers to create individual level piece prototypes, as well as simplifying their cloning and deployment in the levels.

Fig. 6: Screenshot of *Trinity* during a match.

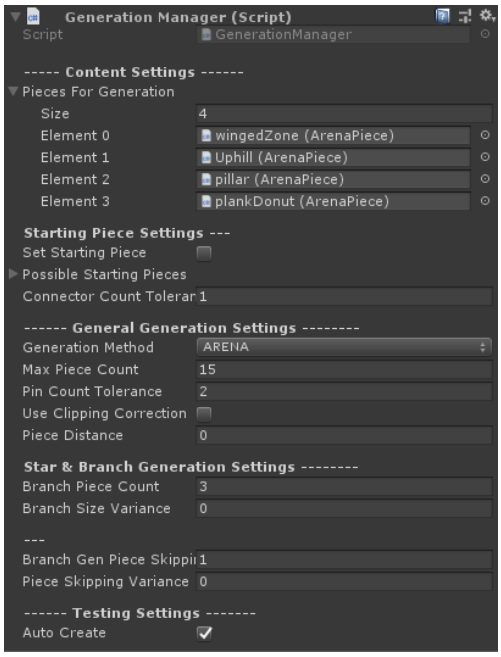


Fig. 7: Parameterization of the generation manager using Unity's inspector.

In the final game, arenas were always generated with the same parameters. However, the MICC approach allowed us to quickly iterate over a number of designs until we were satisfied with the style of arenas being generated. We opted for the *arena* generation method, since it creates large areas without holes where players could fall through – something which was undesirable for this particular game.

4.2 Other experiments

While developing the Unity implementation of the proposed PCG algorithm, we performed a number of experiments which provided us with a better understanding of the algorithms' capabilities, as well as of its limitations. Several levels generated during these experiments, and their relevant generator parameters, are shown in Fig. 8.

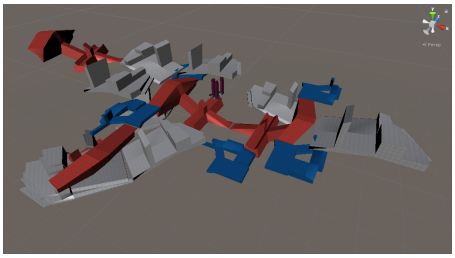
Figs. 8a–8d display experimental levels created with the different generation methods. In Fig. 8e, we used the `pieceDistance` parameter to create a level with "islands" and made the connectors visible in order to help visualize the connections.

Although our approach frees the designer of grid and space restrictions when creating level pieces, care must be taken in their design in order to maintain cohesion and predictability of the generated output, particularly in preventing extreme piece overlapping and looping. In fact, the design of the pieces factors heavily in how generator parameters are chosen. We found that the unique layouts of each generation method became somewhat less obvious as `maxPieces` pieces increased. Some loss of shape can be observed in Fig. 8f, which shows a level with 176 pieces generated with the *corridor* method. Nonetheless, the intended core layout is still noticeable, since the level presents the typical *corridor* "tips", indicating the beginning and end pieces of the generation. Compare, for example, with Fig. 8b.

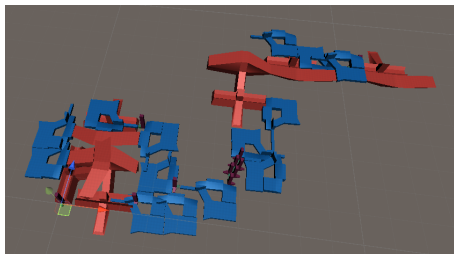
We also experimented with the algorithm in a way slightly different than originally intended. We created small level pieces, props and smaller obstacles, and then reserved all connectors with one pin to unite those small props with bigger pieces of geometry that would otherwise be "empty" without these details. An unpleasant side effect of this was that the levels are much smaller for the `maxPieces` amount given, and the pieces piled on each other. Some examples of this are shown in Figs. 8g and 8h. However, the general idea has great potential as it opens the door for the final design of the level pieces to also be procedurally generated.

5 Conclusions and Future Work

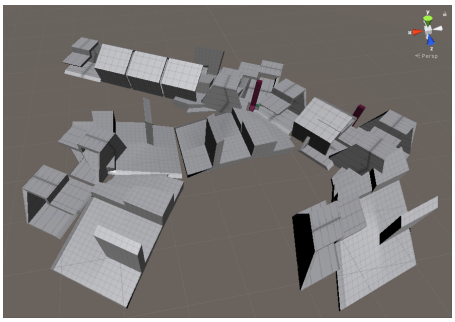
In this paper we presented a MICC-based PCG approach for creating levels primarily aimed at 3D competitive multiplayer games. The proposed method can be used as both a level design and level creation tool, allowing for fast iteration and speeding up development. While the human designer cannot directly manipulate



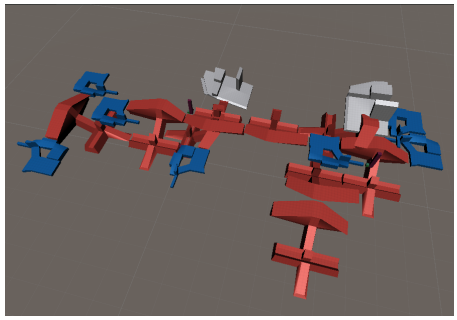
(a) `genMethod` = *arena*, `maxPieces` = 20.



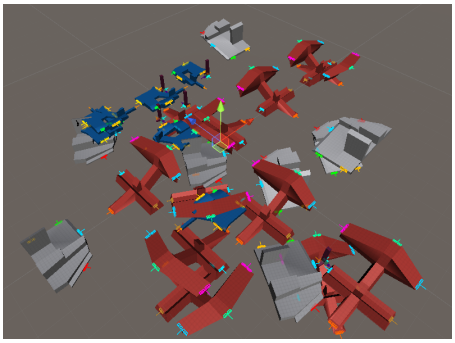
(b) `genMethod` = *corridor*, `maxPieces` = 30.



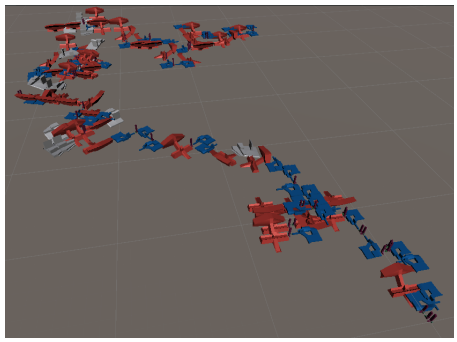
(c) `genMethod` = *star*, `branchPieces` = 8.



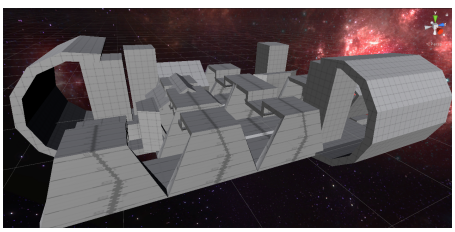
(d) `genMethod` = *branch*, `maxPieces` = 20, `branchPieces` = 8, `pieceSkip` = 1.



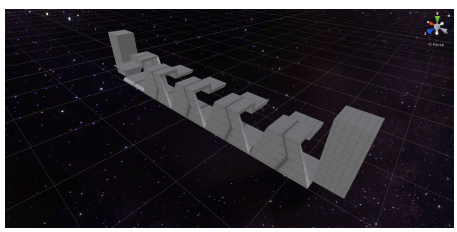
(e) `genMethod` = *arena*, `maxPieces` = 20, `pieceDistance` = 12. Connectors visible.



(f) `genMethod` = *corridor*, `maxPieces` = 176.



(g) `genMethod` = *arena*. One-pin connectors reserved for props and smaller obstacles.



(h) `genMethod` = *corridor*. One-pin connectors reserved for props and smaller obstacles.

Fig. 8: Several experimental levels. Only the more relevant generator parameters in each case are presented.

the final map layout, the different generation options on offer provide enough control for the designer to decide on the general characteristics of the generated level. Unlike several of the MICC-based approaches discussed in Section 2, our technique does not restrict map designs to a grid.

The case studies discussed in Sec. 4, in particular the *Trinity* videogame, demonstrated that the algorithm is able to achieve its intended goals, even though much of its potential is yet to be fully explored. Nonetheless, there is room for improvements. For example, another layer of connector combination constraints could allow the algorithm to combine not only full level pieces, but also props, obstacles and even simple cosmetic changes to those same pieces. Pursuing this idea further, if the algorithm made use of multiple generation passes, it could potentially create levels with several floors, adding verticality to the generated maps. Finally, a more sophisticated way to correct overlapping geometry would also be desirable.

In any case, we believe the proposed algorithm, in its current form, has the potential to be a useful tool for game developers and game designers to create quality levels in a fraction of the time it would take them with a fully human-based approach.

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Shaping User Profiles after First User Validation: Reflections on the Findings of the Prototyping Process of a VR Bird Watching Tour in Lima, Perú

(0000-0002-3335-8928)
Fiorella Carhuancho Quijada

Pontificia Universidad Católica del Perú

fiorella.carhuancho@pucp.pe

Abstract. User Personas have long been used to start creating a design project because it helps the designer understand the end user. However, there is a lack of information and case studies that show how often designers are faced to the problem of what they thought would be the solution is not working as planned when the product is implemented. The aim of this paper is to reflect on how the designer perspective can evolve since the begging of the design process where the user is identified and described until the prototyping and testing with real users. To reflect on this gap the case study of the Work in Progress of VR birdwatching tour in Lima, Perú is presented. Literature review, interviews, participant and not participant observations were conducted during the conceptualization stage of the project and then the prototype was elaborated to validate it. Results show that, whereas planning for an ideal user is useful at the beginning, it is necessary to contrast these profiles with actual users because they can vary greatly during the interaction with the product and the specific context they are applied to.

Keywords: HCI, User Personas, Prototyping methodology, VR, Ecotourism

1 Case Study: Introduction

1.1 About the project

The "Albufera Medio Mundo" Regional Conservation Area (ACRAMM) is located in the district of Végueta, province of Huaura, department of Lima, Perú. It is an important resting place for migratory birds on their annual journey, as it is part of the South Pacific Biological Corridor. However, since the establishment of Albufera Medio Mundo as a Regional Conservation Area in 2007, very little has been done to promote it as a tourist destination. The lack of interest and low environmental awareness present in all the actors involved in the management of the Albufera de Medio Mundo Regional Conservation Area leads to the wasting of the tourist potential that the area has for the practice of birdwatching activities (GORE-Lima, 2015).

Due to the situation caused by the COVID-19 pandemic, all the activities carried out in the ACR Albufera de Medio Mundo were suspended. In August, the doors of the lodge at the entrance to the area were reopened, but currently there are no approved biosecurity protocols to carry out tourism activities safely.

For this reason, the project for the design and implementation of a Virtual Reality tour aims to contribute to the use of the tourism potential that the Albufera de Medio Mundo Regional Conservation Area has to offer.

1.2 Implications of the "new normality" context

The COVID-19 pandemic has strongly affected the tourism sector in our country. In recent months, the activation of the sector has begun to be rethought in regions that are not in targeted quarantine. On August 20, the Ministry of Foreign Trade and Tourism of Perú approved by Ministerial Resolution No. 171-2020 the "Health Protocol for adventure tourism, canoeing and hiking." With this, around 1000 travel agencies in the country are expected to start their operations (Gobierno del Perú, 2020). According to the National Chamber of Tourism, Promperú is working on a campaign to encourage a return to tourism. This will be developed in coordination with regional governments, regional directors of tourism and other unions in the sector so that safe tourist circuits can be developed (RPP, 2020). Despite the efforts, it is necessary to design proposals that contribute to the economic reintegration of the tourism sector, especially that of small entrepreneurs. This project is being developed in conjunction with a small ecotourism agency that operates in the area.

1.3 Stage of development

The project presented here is a Work in Progress. A first validation with potential users has been made and it has allowed the researcher to better understand the initial user profiles that were elaborated during the conceptualization stage. After hitting this first milestone, the researcher reflects on the results shares them with de academic community, to then make appropriate decisions regarding the design of the product in the next phases of development.

2 Methodology

2.1 Conceptualization

User Research. In the conceptualization stage, the first step consisted of identifying the end users. This phase made it possible to define their characteristics, understand their motivations, and observe their behaviors.

To conduct this first stage, methods derived mainly from three areas of research have been used: Human-Computer Interaction, Anthropology and Marketing (See Table 1).

Table 1. User Research table summary

USER	CHANNEL	TYPE OF EVENT / PLACE	METHOD	DATE
Artist	In person	Event: 1st drawing workshop organized by the Sudamerican Watchers travel agency.	Participant observation	March 2020
		Graphic designers and visual artists	Conversation	March-April 2020
	Virtual	Illustrator profiles on Instagram	Non participant observation (Netnography)	August 2019 -April 2020
		Youtube: The Futur, Draftsmen Podcast	Indirect observation	
Scientific (Biology, Ecology)	In person	Ornithology expert - Museo Nacional de Historia Natural SM	Conversation	March 2020
		Letty Salinas - National Museum of Natural History SM - Peru	Participant observation	February 2020
	Virtual	Clara Cerviño - Biologist, Illustraciencia professor Event: Course of Scientific Illustration of Birds (Illustraciencia-Spain)	Participant observation	March-April 2020
		Profiles of biologists and scientific illustrators on Instagram	Non participant observation (Netnography)	March-April 2020
		IlustraTalks - by Illustraciencia	Non participant observation	March 2020
		Event: Virtual meeting with Global Youth of Biodiversity Network - Peru Chapter	Participant observation	April 2020
		Live Talk A Window Into Science - The Importance of Scientific Drawing in science museums (Cosmo Caixa-Barcelona)	Non participant observation	March-April 2020
Tourist / Birdwatcher	In person	Guided bird watching tour Directed by birdwatching expert	Participant observation	September 2019
		Event: World Wetlands Day in Pantanos de Villa	Participant observation	February 2020
		Bird Watching Workshop Directed by birdwatching expert	Participant observation	February 2020
		Birdwatching Albufera Medio Mundo	Participant observation	February 2020
	Virtual	Virtual conversation: Bird tourism in Colombia	Non participant observation	April 2020
		Virtual Workshop: 'Urban birds of the province of Lima and Global Big Day '	Non participant observation	April 2020
		Virtual talk: Effective Management of SINANPE	Non participant observation	April 2020
		Tourist profiles on Instagram	Non participant observation (Netnography)	August 2019 -April 2020
		Profiles on travel websites: TripAdvisor, AirBnB, Booking	Non participant observation (Netnography)	August 2019 -April 2020
		Youtube: Videos related to experiences and / or tutorials on bird watching	Indirect observation	March-April 2020

As can be seen in the table above, the potential identified users are three: Artists, Scientists and Tourists. This decision was made after analyzing which profiles would be potentially interested in the product that is being developed.

The first type of user "Artist" was identified from the first guided visit organized by the ecotourism agency on March 7, 2020. This activity consisted of a drawing workshop with potential users in the study area. The activity lasted one day and during the visit / workshop the behaviors and motivations of those who would be part of the target audience were observed. The information collected was then contrasted and complemented with other observations that emerged from conversations with people with similar profiles and through the observation of the online behavior (mainly on Instagram) of other artists, designers and illustrators. One of the tools used to systematize the information collected was the creation of User Personas. Another tool used is the Empathy Map. This is usually a good complement after having identified the 'User Persona", since it delves into more subjective and sensory aspects of the user experience.

The second user profile is the "Scientist". This was identified from conversations with scientists (biologists and ornithologists) of the Natural History Museum of the UNMSM Peru and the participation in online events with members of the Global Youth Biodiversity Network – Peru Chapter and participation in the online course of scientific illustration of birds dictated by a biologist. Two Customer Journey Maps were carried out to systematize the experience of the drawing workshop and the online course.

The third identified User is the "Tourist". This profile was prepared from the review of specialized literature and the netnographic observation of its behavior on the main travel platforms (TripAdvisor, Airbnb, Booking and Instagram). In the literature search, two types of tourists were found. The first is the so-called "experience seeker" tourist, who always tries to learn something new, experience authentic experiences, challenge

himself at both the emotional as well as mental and enjoys a lot of knowing natural or cultural environments that have not been explored before (SERNATUR Chile, 2017). The second type refers to the specific activity of birdwatching. Among the existing birdwatcher profiles, Occasional Observers and Softcore observers have been selected, who are not very interested in participating in world and exclusive bird watching championships, but, on the contrary, show greater fondness for Interpretation Centers. Both Occasional Observers and Softcore observers take time to enjoy other fun and cultural activities. For this reason, they usually visit not only protected areas, but also museums, exhibitions and art galleries (PROMPERU, 2013).

Finally, regarding the three types of users selected, it is important to note that dividing them into three different categories is due to a rather practical reason because it allows us to be clear about what differentiates them and what their particular needs are. However, this does not mean that the profiles are so limited, as there may be some that share characteristics of up to two of the users described (eg, an artist who is also a tourist "experience seeker").

Task Analysis. The objective of this phase within the conceptualization stage is to systematically understand how users currently carry out activities. The emphasis is on the tasks that each one does step by step and not so much on the technology they use to do them. Three task analysis were carried out dividing tasks into two types of analysis: Hierarchical Analysis in which the tasks are divided into subtasks and the second is the Cognitive Analysis (Soegaard & Dam, 2013) in which not only the way in which each task is carried out is analyzed but other details such as what motivates it to make a decision or what is the level of knowledge required prior to the experience.

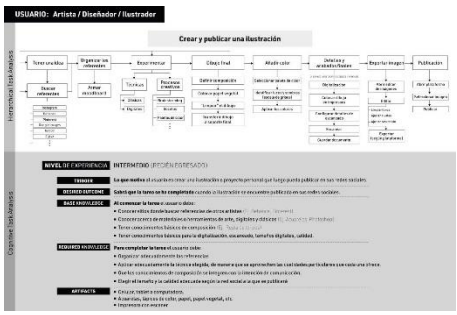

Fig. 1. User “Artist” – Task analysis: Create and publish an illustration

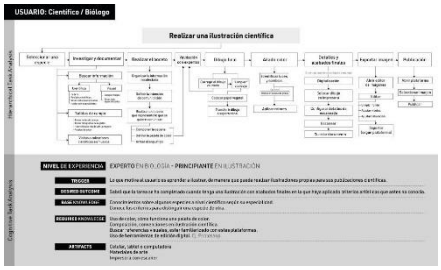

Fig. 2. User “Scientific” – Task analysis: Create and publish a scientific illustration

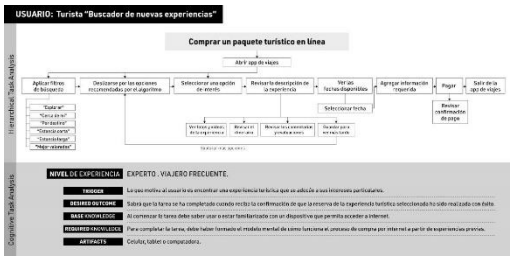

Fig. 3. User "Experience seeker tourist" – Task analysis: Make an online reservation of a tour

Ideation. Once the analysis of user behaviors, their tasks, motivations, as well as the contexts in which they will develop their activities has been carried out, the ideation process begins. Braindumping was the technique used in this part of the process. Unlike 'Brainstorming' which is a method used for the collective generation of ideas about a design problem, 'Braindumping' (Interaction Design Foundation, 2020) has the same objective, but consists of an individual session in which the aim is to point out as many possible solutions. Session duration: 30 min.

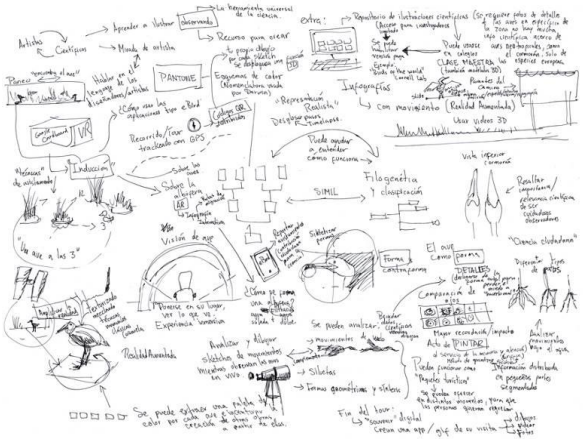

Fig. 4. Braindumping result of the 30 minutes session.

Conceptual Modelling. This phase consisted of creating a conceptual model based on a metaphor. The metaphor selected was "Site Museum", this allowed the designer to identify common elements that users are familiar with, with the goal of making the product easy to use. During the development of the prototype, the idea is not to literally replicate each one of the elements identified in this part, but to understand their function within the context and evaluate how they could be present in the new digital environment.

Interaction or Task Scenarios. The last part of the conceptualization stage is the elaboration of the Interaction Scenarios, consisting of a set of images, similar to a storyboard, that allowed the designer to visualize the possible scenarios in which users would interact with the product / service. This is an essential part of the design process, since it is the guide to develop the prototype that will be validated later with the users.

Fig. 4. Interaction scenarios for the VR birdwatching tour project.

2.2 Prototyping: Functionality, Interactivity and Spatial Structure

For the development of the prototype, the approach was the one proposed by the authors Lim et al. (2008) in the article "The anatomy of prototypes: prototypes as filters, prototypes as manifestations of design ideas". They state that prototypes should not only be seen from the perspective of how close they are to the final version of the product (which normally happens when talking about low, medium and high-fidelity prototypes) but to understand them as an instrument that allow designers and developers to manifest in a tangible way certain aspects or dimensions of a design proposal.

Table 2. Filtering Dimensions and Example Variables by Lim et al (2008).

Filtering Dimension	Example Variables
Appearance	size; color; shape; margin; form; weight; texture; proportion; hardness; transparency; gradation; haptic; sound
Data	data size; data type (e.g., number; string; media); data use; privacy type; hierarchy; organization
Functionality	system function; users' functionality need
Interactivity	input behavior; output behavior; feedback behavior; information behavior
Spatial structure	arrangement of interface or information elements; relationship among interface or information elements—which can be either two- or three-dimensional, intangible or tangible, or mixed

For the validation of the first prototype, three of the filtering criteria proposed by the authors were selected: Functionality, Interactivity and Spatial Structure. InstaVR, a web application, was used as the main platform for the development of the prototype. Some of the resources used for the prototype were 360° videos and photos, sounds, a 3D modeling of a bird and 2D buttons with sound. The prototype was made up of five interaction scenarios, one main and four secondaries.

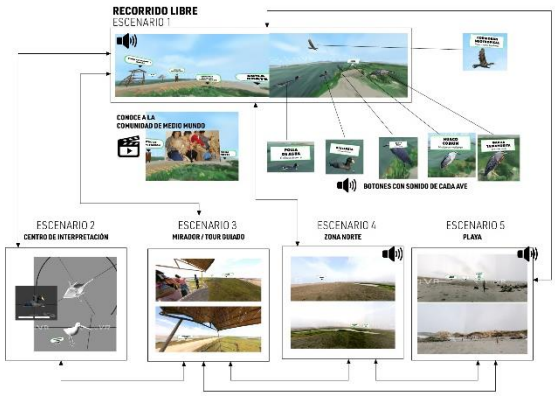

Fig. 5. Planning of the interaction scenarios

2.3 Validation

Seven participants were recruited taking into consideration their profiles in relation to the potential users identified previously during the User Research process. Four sessions were held, two group sessions, consisting of 3 and 2 people, respectively, and two individual sessions. Given the COVID-19 pandemic context, remote validation sessions were scheduled with each of the participants according to their availability and boxes containing the virtual reality glasses were distributed to each participant, through a delivery service.

The group sessions lasted between one hour and one hour and a half, and the individual sessions lasted twenty minutes and forty minutes, respectively. Participants were asked, one hour prior to the start of the session, to download and install two mobile applications: one to record the cell phone screen which was going to be later analyzed by the researcher, and the other was the prototype application according to the operating system of their mobile phone (Android or iOS).The session was carried out through the Zoom platform and was structured in three parts. In the first part, users were asked to start recording their cell phone screen and then access the prototype application to explore the content. They were not given instructions on how to use the application because one of the evaluation criteria was to measure how intuitive the interface was. In this first part, two moderation techniques were used: Concurrent Think Aloud (CTA) and Concurrent Probing (CP) (Usability.gov, n.d.). The first is for the participant to communicate what is going through their mind while using the prototype. The second complements the first method, since it consists of the moderator asking questions when the participant is doing the action, to understand the interaction between the user and the prototype.

Fig. 7. Remote testing session through Zoom.

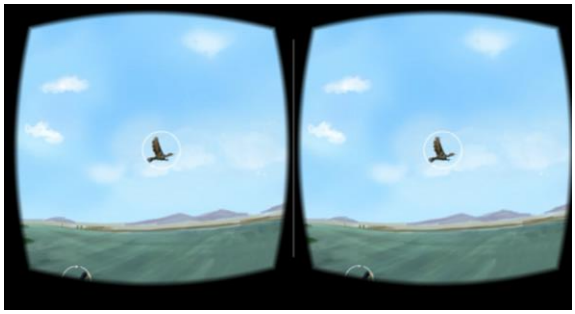

Fig. 8. Screenshots of participant's point of view (sky)

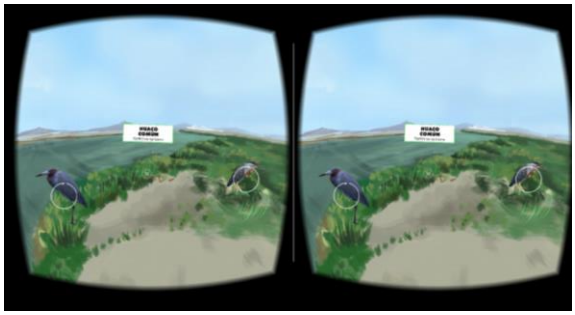

Fig. 9. Screenshots of participant's point of view (interaction with birds).

After each participant finished exploring the virtual content, they went on to the second part of the session, in which the moderator gave more details about the context of the project so that the participants could reflect and relate the experience they had had with the objective of the project. In this part, the Retrospective Probing (RP) method was used, in which participants were asked to answer some questions regarding the interaction they had had with the prototype, such as difficulties that arose, how the system worked, what did they most enjoy the experience and if it was easy to understand the dynamics.

At the end of the session, participants were asked to send the videos corresponding to the recording of their screens during the experience for further analysis.

3 Results

Regarding the analysis category of System Functionality, the result obtained was that the participants who had iOS as their mobile phone operating system invested twice the time during the download and installation of the mobile app. According to three of the users they experienced problems when using the virtual reality application with the lenses, two of them did not have mobile devices with a gyroscope sensor (see Figure 9) and their mobile devices had a limited RAM memory so they only saw a black screen with floating buttons and the application did not respond to the rotation movement made by users. They had to test the prototype through the web platform. One of the users did have the gyroscope sensor, however, she experienced a delay between the physical movement made with the head and the response of the system. At times the image was static and did not allow the interface to continue rotating. Once the application was restarted, this problem was solved. Regarding the hardware, the VR lenses, all the users experienced a blur in the image displayed on their mobile devices when they had the lenses on. In particular, users who wear glasses in their daily life had this problem, and had to hold with their hands the VR glasses above their normal lenses. This greatly detracted from the experience, and one of them preferred to only use the mobile phone screen without the lens, to avoid the feeling of dizziness.

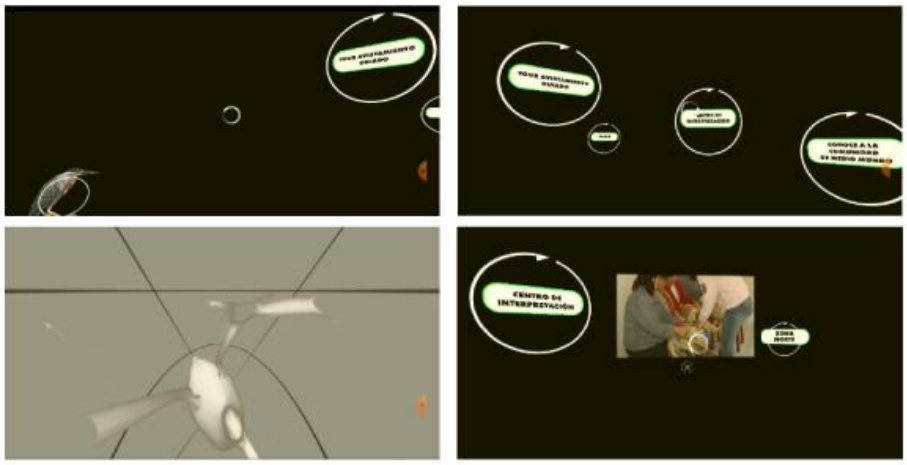

Fig. 9. Screenshots of the views of the participants whose devices did not have a gyroscope sensor.

In the Interactivity category, all users had trouble recognizing, intuitively, how the buttons worked and what they were expected to do. Some were confused by seeing so many options on the first screen and were frustrated for not knowing how to make the buttons work. They took up the first 40% of the session just trying to figure out how the button and scenario dynamics worked. In the last quarter of the session, everyone had already understood how the system worked and did it more fluently. Despite this, there were certain buttons that, because they were very close to each other, did not respond to user input. In some cases, due to very sensitive gyroscope sensors, scenarios that were not requested by the user were activated, this also caused users to get frustrated. All users indicated that buttons that were too far apart in three-dimensional space could not be read, so they could not interact with them. Four users indicated that their favorite part of the experience was the scenario where they could interact with the birds, see their names and hear their sounds. Three of the users indicated that their favorite part of their experience had been scenario number 5, since it was a 360° photograph with sound of a real beach environment, they felt that they were transported to that scenario and mentioned that it made them feel very good because after the long period of confinement, they wish to go back to the beach. They mentioned that this was a enjoying the landscape without risking their lives. They pointed out that this experience is the closest they felt since the last time they visited a similar place. For some, it brought back memories of experiences from their childhood.

It should be noted in this regard that, although this prototype did not seek to evaluate the aesthetic dimension of the product, it was inevitable that the response of the users was not influenced by this dimension. Scenario 1, unlike the other 4, presented a scenario made from a 360 ° panoramic illustration while the other 3 presented scenarios generated from photographs, although they did not have high definition like the illustration one, users were more attracted by the images that represented a real environment. When asked the reason behind this preference, they commented that this was

influenced by the situation of the pandemic. They commented that, in the old normality, they would have preferred illustration because it is something different that breaks their visual routine of seeing scenarios in real life. However, in this new normality, all the content they have been observing is digital, so now that disruption in their routine occurs when they are placed again in an environment that simulates a reality they know.

Regarding the category of Spatial structure, it was identified that users do not understand the place spatially, that is, only at the end of the interaction, did they realize that the position of the buttons that lead to the other scenarios responds to the actual geographical layout of the Albufera de Medio Mundo Regional Conservation Area. One of the users commented that in real life she has problems for locating herself geographically (to find streets or addresses, for example) and that, as this usually happens, she does not expect to orient herself spatially in a virtual environment either. On the other hand, in the transition from the illustration and photography scenarios to the Interpretation Center, which was a scenario generated entirely in 3D with a giant bird in the middle, they found it interesting once it was explained what the dynamics would be when the product is finished. However, at first, while exploring the app on their own, they felt disoriented when entering this 3D space because the first thing they saw is a giant tube floating in the middle, which they later recognized was the leg of a large-scale bird. Of the evaluated users, 5 of them did not discover this by themselves, the moderator had to indicate that they should look up to discover what they were actually seeing. It is concluded that there is a spatial break between one scenario and another that must be improved.

An important point to highlight is that of the 4 users who tested the product with the VR glasses, only one intuitively left her chair and stood up to use it, the other 3 remained seated. The physical space in which 2 of the participants were found was limited (between a desk and a wall) so that on several occasions they came up against obstacles in their rooms. Users must be warned prior to the experience about this issue to avoid accidents during the use of the product.

After analyzing the three categories proposed, users were asked what they thought about the experience in general and if, after having listened to the explanation, they considered that it be a product they would pay for. The answer was unanimously positive, but the clarification was made that they would only do so if the aspects in which they had had difficulties were improved. Regarding the motivation to hire a service like the one they experienced in the testing, four of the participants mentioned that what would motivate them to pay for this experience would be the curiosity to test the interactive aspect and the exploratory nature of the virtual tour and not so much the experience of "traveling" or learning about birds. They feel that it is an added value, but what they enjoy the most is exploring the setting and seeing what happens when they discover by themselves the options presented. One of the participants mentioned that what would motivate her is not only to show the birds and the natural environment, but to establish a connection with the people who live and work in the area producing handicrafts with reed, because it was aligned with a particular interest of hers. Two of the users mentioned that what would motivate them to pay for this experience is that they would have the opportunity to feel, even if it is for a few minutes that they are traveling to a place outside their home.

4 Conclusion

It is concluded that the project to implement an interactive virtual platform is a proposal with the potential to attract not only the public who have a particular interest in birds or travel, but it also might appeal to an audience that is attracted solely to the interactive aspect. This could represent a unique opportunity to take advantage of the medium and disseminate scientific knowledge to a non-specialized public in an entertaining way.

There are aspects that have to be improved in terms of functionality, interactivity and spatial structure to improve the user experience. Some of these improvements should include the introduction of an introductory video that explains how to use the platform as a tutorial, to reduce the cognitive load on users. Aspects of the interface and internal structure should also be improved to ensure the effective response of the system to user input and that at the same time it is pleasant to use.

Finally, regarding user profiles analyzed in the first part of the research process we can conclude that, although in the first phase profiles were very limited and structured, later, with the validation of the first prototype we realize that many assumptions that we made during the first phase are not entirely true, therefore it is necessary to make adjustments in the profiles in relation to the emotional and functional response evidenced on the behavior of users while using the prototype tested.

5 Limitations and Future Research

Technical limitations were presented during the validation process, therefore, of the 7 users recruited to do the testing, only 5 could be effectively evaluated, since they were the ones that did have the system requirements on their mobile devices to execute the test of the virtual reality application. Feedback was also received from the remaining two users, but the experience was lived through the web platform, so it was not possible to evaluate each of the 3 categories in the planned way.

Another limitation that was presented in the validation of the prototype is about the poor quality of the lens that made the image look out of focus. This caused the user to spend time trying to focus the image and, not being able to do so, greatly detracted from the experience, since the images were not appreciated with quality, so for the following validations, the acquisition of equipment with better quality should be considered.

The results presented in this stage correspond only to the validation of the dimensions of functionality, interactivity and spatial structure, so a prototype is needed prior to the high-fidelity prototype in which the aesthetic dimension is evaluated, with high-quality photographs in 360 ° and a sample of the style of the final illustration to decide if one of the two options should be chosen or if both can be integrated. In the new prototype, the data or content dimension must also be validated. The information sheets on each species must be validated by an ornithologist or biologist to ensure that the information to be transmitted is scientifically correct, after such validation the content can be organized within the virtual experience under criteria of hierarchy and type of

information, to generate an experience that responds to the interests identified in the users after the first validation.

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Macguffin: Reimagining Pac-Man to encourage inclusion and reduce stigma associated with visually impaired people

Dinis Enes,[1] Livia Lopes,[2] Frederico Oliveira,[3]
Pedro Cardoso[4] [0000-0001-8546-4194] and Bruno Giesteira[5] [0000-0003-4896-6659]

[1] Faculty of Engineering, University of Porto, Portugal
[2] Faculty of Engineering, University of Porto, Portugal
[3] Faculty of Engineering, University of Porto, Portugal
[4] Lusófona University, HEI-Lab Digital Human-Environment Interaction Lab & Faculty of Fine Arts of the University of Porto, Portugal
[5] INESC TEC, Faculty of Fine Arts, Design Department, University of Porto

[1] dinis.enes@gmail.com
[2] oi@livia-lopes.com
[3] up201604833@fe.up.pt
[4] pcardoso@fba.up.pt
[5] bgiesteira@fba.up.pt

Abstract. The implementation of Universal Design in our daily lives is raising awareness and changing behaviours with the purpose of being inclusive towards people who suffer some type of disability. In this paper, we explore how to make games inclusive for visually impaired people. To achieve this, we've created a remake of *Pac-Man* (1980) called *MacGuffin*. We resorted to co-design sessions to identify challenges visually impaired individuals face when playing video games and to find ways to mitigate them when designing these. Co-design sessions and navigation efficiency tests were accomplished to improve mechanics and implement features like haptic feedback. Results show some areas like sound effects, interface and the tutorial need further work, with participants showing interest in the development of a physical device. The creation of *MacGuffin* shows that games like *Pac-Man* can be inclusive and accessible using Universal Design, while providing hints for the design of inclusive games.

Keywords: Accessibility, Game Design, Universal Design, Visually Impaired.

1. Introduction

Currently, 2.2 billion people have a visual impairment, and one billion of those cases are caused by underlying conditions such as glaucoma, cataracts, or diabetic retinopathy [1]. Many of those affected within this group lose some quality of life because, when available, the majority of products and services are adaptations from non-disabled design. Bias against visually impaired people is another factor contributing to decreased wellbeing and can be explained by the Rosenthal Effect [2], a phenomenon that shows how powerful suggestion can be, e.g. if family, friends, or support organizations have low expectations on the disabled community they risk promoting insecurity in these people [3].

To avoid adaptation or specialized design that can reinforce and potentialize the Rosenthal Effect, it is necessary to study mechanisms that provide equal opportunities for everyone, regardless of their disability. Universal Design[1] can be a tool to achieve these goals. Universal Design declares that "the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design." [4]. This aims to achieve an inclusive society with equal opportunities for everyone, regardless of age, sex, or disability, by designing products, environments, and services suitable for everyone [4]. When we address multimedia products, such as video games, and realize that most of them are largely inaccessible to disabled people, including visually impaired individuals.

Our motivation is then to reimagine mainstream video games and understand what rules and mechanics are more important to provide an inclusive game experience, designed for everyone, including visually impaired individuals. In this paper, we demonstrate how a game's design can be improved by resorting to co-design methodologies, including its final users as participants in the design process, discuss ideas through iterations, and considering their feedback to design a suitable product. We reimagined the popular game *Pac-Man* (1980) considering Universal Design concepts, designed, tested and adjusted it with our participants as consultants.

This paper is composed of 4 sections. In section 2 (Description), we provide the context of a game we designed and explain its gameplay mechanics. In section 3 (Process and Tests), we describe our work methodology, the tests we conducted, and

[1] Universal Design can evolve into another concept called Inclusive Design, which focuses on adjustments for specific groups, like visually impaired persons, by adding special equipment for them to use, such as audio or tactile books [4]. These efforts in inclusive design rely upon the previous structural work done with universal design, making for a faster and better implementation [5].

the characterization of the sample of participants. In section 4 (Results), we present the data from the tests. Finally, we draw some Conclusions and present Future Work, in section 5.

2. Description

2.1 Context and game concept

The idea to design and create an inclusive game oriented for the visually impaired people emerged from the challenge proposed in the course of Multimodal Interfaces of the Multimedia Masters at Faculty of Engineering of the University of Porto: to design an inclusive interface. The course's lectures raised awareness and promoted interaction with the Inclusion Support Center of the University of Porto[2] (NAI), which goal is to promote a technological, physical, human, and learning environment that can be accessible and universal within the academic community.

This contact with NAI was fundamental to our project as it offered us solid support to mitigate the low amount of visually impaired participants and gave us fruitful feedback during the co-design sessions (which we will explain in section 3) and together with three other international participants from a gamer's Facebook group entitled Blind Gamers. As a result, we were able to identify two key obstacles: 1) a lack of mainstream games for the visually impaired that could bring more interaction with the general public; and 2) a scarcity of platforms able to adapt to the needs of their players.

Designing for and with the users brought us strong insight into our work process. We used surveys and co-design sessions with our participants to trace an adequate user profile. Due to the lack of response from ACAPO[3] and the limitations imposed by the COVID-19 pandemic, our capability to outreach a significant sample of visually impaired people decreased from what was initially planned. We then sent a second

[2] Núcleo de Apoio à Inclusão da Universidade do Porto (Inclusion Support Center of the University of Porto). NAI supports the University of Porto in its work to recognize and esteem diversity and to promote justice and equity in access to knowledge, learning, and research.

[3] Associação dos Cegos e Amblíopes de Portugal (Portuguese Association of the Blind and Partially Sighted).

questionnaire conceived for the gaming community from the University of Porto and obtained a total of 105 answers. Of these, 102 play electronic games daily and recognize that the games offered on the market are not inclusive for groups with disabilities, with a higher rate regarding the visually impaired.

Afterwards, we started our conceptual phase by brainstorming some concepts, discussing what type of game should be created and how should it be played. Due to the high number of references about the lack of mainstream games adapted for visually impaired people, we decided to work with a reimagined version of the world-famous *Pac-Man* (1980), featuring a multimodal and multiplayer structure to mitigate differences between players and encourage interaction, regardless of their limitations.

The choice of a popular game was conscious, as was the use of available and accessible resources to take advantage of the smartphone and its built-in features, with an aesthetically pleasing interface. For a possible future physical prototype, we considered materials and resources with low financial costs imagined to enhance the sensory experience.

We adopted Universal Design principles that are flexible to use on a large layer of individuals, including, for example, a customizable profile where the user can adapt the game to his capabilities.

We called this game *MacGuffin*, a term coined by Alfred Hitchcock to designate an object, event, or character from a film or story which allows the plot to keep moving despite lacking intrinsic importance, ultimately being a means to achieve an end.

2.2 Gameplay

MacGuffin is a multiplayer game similar to *Pac-Man*, featuring a maze that has to be travelled by the players, who have collect a set of *tokens*[4] scattered around the area

[4] Tokens may represent fungible or infungible units of value in the form of money, coins, points, digital items, or representations of real-world physical items and rights, definition extracted from www.gamejolt.com/help/tokens (last accessed 2020/10/08).

while avoiding attacks of opposite players. The player never sees the maze on screen.[5] Haptic and audio signals assist the player in navigating the maze, function as alert signs for when enemies are nearby, and provide feedback when hitting the walls.

An optional graphical user interface for playing is also available, featuring arrow controls for the main player, and a position indicator on the screen (where the maze remains hidden) for the opponents, where audio alerts become visual signals on the screen. Figure 1 shows some drafts of the appearance of the game screens.

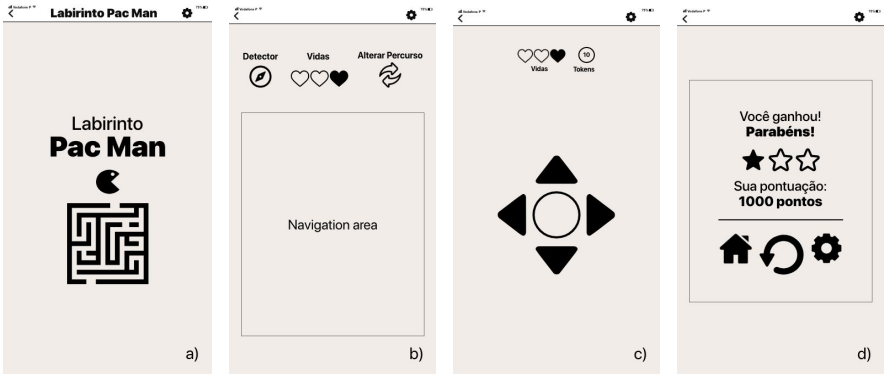

Fig. 1. Screen mockups of: a) game opening screen; b) opponent players' graphical user interface; c) main player's graphical user interface, with optional visual controls; and d) scorescreen example.

At the beginning of the game, one player is randomly chosen to control the main character (*MacGuffin*), becoming the *main player*. When *MacGuffin* collides with the path of other players, he loses a life. The same happens upon failing to complete the maze in time. The game is over when the main player runs out of lives. The complete set of rules for the main player's can be found in table 1.

Table 1. Objectives, Rules and Game Interface for the Main Player

Main Player's rules	Main Player's Goals	Game Interface
– Player 1 has three lives.	– The main goal of player 1 is to collect all the *tokens* in the	– Visual handling controls.

[5] If the player chooses to play solely with the audio option, the game features no visual elements for playing and navigating the space.

– If player 1 collides with one of the other opponent players, he loses one life. – The number of lives is maintained as the player progresses in the game. – During the round, player 1 can collect bonus *tokens* that give him a 5 second window of immunity to escape his opponents.	maze before time runs out. – Avoid opponents' attacks. – Stay alive until the end of the game.	– Lives. – Token count.

The role of the *opponent players* is to prevent MacGuffin (the main player) from collecting all tokens in time, hitting him to take his life. Their actions are controlled through the interface on the opponent players' smartphones, networked to the one running the game. Through this interface opponent players may also rearrange the maze three times and move randomly in it. Their attacks are enacted by sliding their finger through a depicted area on the screen of the smartphone, which doesn't reveal the maze (Fig.1b). MacGuffin's approximate location is unveiled by a proximity sonar-like blip or, if selected, a haptic signal that vibrates, or a visual proximity detector with an arrow pointing to MacGuffin's approximate direction.

Table 2. Objectives and Rules for Opponent Players

Opponent Players' Rules	Opponent Players' Goals	Game Interface
– Opponent players can change the maze randomly three times. – Move randomly through the maze to hit MacGuffin.	– Prevent MacGuffin from reaching the end of the maze. – Take lives from MacGuffin.	– Maze navigation area. – Other opponent players and MacGuffin. – MacGuffin detector. – Option to randomly change the maze.

3. Process and Tests

3.1 Participant sample characterization

To test the main player's game mechanics we required people with and without visual impairment with interest in the gaming universe and that frequently play digital games.

The first main goal of our questionnaire was to understand the interests of a typical gamer, without visual impairment, aiming to comprehend:

- Gender, age and academic background of the participants;
- The type of games participants use to play (e.g. board games, puzzles, card game, digital games);
- The frequency participants play games;
- The participants' point of view regarding usability in games towards visually impaired people.

This questionnaire obtained a total of 105 responses. From this sample we obtained the following data:

- 70.5% had 25 years or less;
- 55% were men and 45% women;
- Of these people, 102 play games, with a large number of people preferring electronic games on a daily basis, as shown in figure 2.

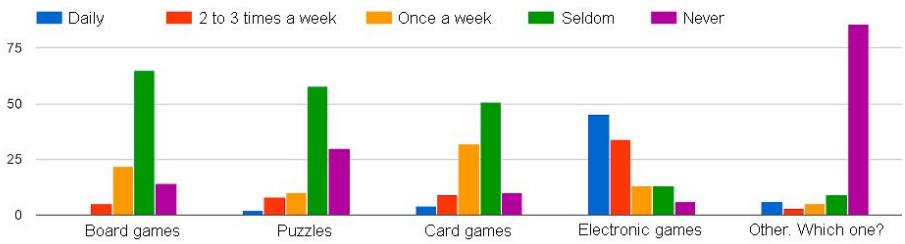

Fig. 2. Frequency in which the surveyed participants play games.

The contact with the visually impaired players was made through NAI, as well as through a Facebook group called Blind Gamers, constituted by groups of visually impaired players who work in game development or are interested in games.

For this group we made co-design sessions and navigation efficiency tests. The data can be observed in Table 3, where we list the participants' professional occupation, previous experience with games, the quantity and type of tests they performed.

Table 3. Participant sample characterization of the co-design sessions and navigation efficiency tests

Participant	Visually impaired	Occupation	Game Experience	Test Quantity	Test Type
P1	Yes	Support organization coordinator	Average	4	2 co-design sessions and 2 navigation efficiency tests
P2	Yes	Project Coordinator	Low	1	2 navigation efficiency tests
P3	Yes	Designer for people with special needs	High	2	1 co-design session and 1 navigation efficiency tests
P4	No	Project Coordinator	Average	2	2 navigation efficiency tests

The development took place during the first quarantine period in Portugal (March to May 2020) caused by the COVID-19 pandemic. Because of that, we decided to make some tests in remote capacity to ensure the safety of the participants. The tests were split into three phases: 1) *information gathering*, 2) *user feedback*, and 3) *revision*.

3.2 Phase 1: Information gathering

The objectives for *phase 1* (*information gathering*) were to:

1. Understand and validate potential ideas for game design;
2. Understand the main concepts of inclusion to be addressed in the project;
3. Know which devices were used most frequently (smartphone, tablet);
4. Know players' habits.

During this phase we collected information from our target audience in order to understand what problems they faced and how to solve them. This was accomplished with one questionnaire sent to the students of the University of Porto and with co-design sessions to visually impaired individuals contacted through NAI and Blind Gamers.

3.3 Phase 2: User feedback

Phase 2 (*user feedback*) had the following objectives:

1. Co-create the main mechanics and features of the game with the participants;
2. Create a baseline of user performance regarding game mechanics and gameplay, game environment, audio and navigation;
3. Get an insight on audio efficiency;
4. Collect feedback from the test participants.

To do so, we analysed the data gathered in phase 1. This was accomplished with co-design sessions with end users, in which they tested the level design and the game's navigation system.

For the assessment of the results we considered two important metrics for the gameplay: *navigation efficiency* and *audio efficiency* of the game experience. The first, is concerned with the efficiency of the player's performance in navigating the game space – test 1. The second is focused on how efficient each audio element is in its intended affordances, focused on gameplay and players' actions – test 2.

Test 1: Navigation efficiency

Before the navigation efficiency tests exercise session with the test subjects, we created a hypothetical use scenario as a resource to create the first outline of the game. After the level was designed, we then transposed it to an audio recreation of the path, which our participants would have to do. The audio consisted of several sounds

participants had to previously learn in a narrated tutorial level. Each sound symbolized the interactions with the labyrinth and the environment. The participants' role was to listen to the narration and trace the path according to what they were hearing. We could then compare the resultant path drawn by the participants with the path we had traced for the game level.

First participants struggled to learn the intended meaning of the sounds. As a result, we added a tutorial (level 0) and sounds that corresponded to the player's actions, and set the audio to a slower speed (about ¼). The test also underwent small adjustments in speed and duration, according to the feedback obtained from these first participants. After such improvements, we designed the following tasks for the test:

1. Before each session, we held a meeting with the whole team to explain how the test was going to be processed.
2. Participants listened to an audio tutorial to get familiarized with the sounds and then proceeded to draw a path following the in-game audio guides. The participants drew the orientations on a sheet of paper (with pen or pencil) and shared the results by email. The route had eight main points to follow to complete the path. One of them is represented in figure 3.
   The execution time was not predetermined, and the participants had the time they needed to complete the task, as they could manipulate the timeline.

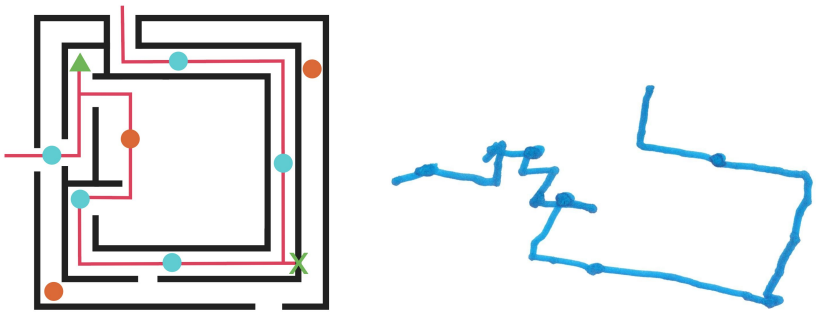

Fig. 3. Experimental level created for the test on the left compared with the participant's resultant path on the right.

Despite the fact that this test resorted to paper and pen instead of a graphical user interface in a digital game, it proved to be a valuable tool for collecting data on the *navigation efficiency* of the system by comparing the path featured in the audio file with the one drawn by the testers.

Test 2: Audio Efficiency

For the audio efficiency tests we performed the following tasks:

1. We held a discussion session with the participants, scheduled after the navigation efficiency tests, to identify difficulties they felt and listen to their suggestions for improvement.
2. During the sessions, we didn't ask direct questions. We had informal conversations instead, with few interventions to encourage a spontaneous opinion of our participants.

3.4 Phase 3: Revision

The goals of phase 3 (revision) were:

1. Implement the adjustments to the level design according to the participant's feedback from the previous test;
2. Validate these adjustments through new co-design sessions;
3. Test and co-design sessions with a new group of visually impaired participants;
4. To get insight on the level of audio efficiency;
5. Interview to collect additional feedback from the participants.

During this phase, we made changes to the level design and audio taking into consideration the suggestions of the test subjects. At this point, we also included members of the Blind Gamers Facebook group in the tests, due to their knowledge in the field of game design. We held these sessions remotely, interviewing them through Zoom and Facebook Messenger.

The co-design sessions with the participants consisted of a dialogue to update them about the game's recent implementations, receive validation for all the phases performed so far and understand if the game is playable.

4. Results

4.1 Phase 1: Results of the co-design sessions

The co-design sessions evidenced the following needs:

a) Create complex configurations with as many components as possible for the user to customize (mainly the option to customize players' controls);

b) Add haptic feedback due to its importance in the experience of visually impaired players;
c) Voice customization to refine and create more personality into the game;
d) Develop a physical device with an affordable financial cost;
e) Design a game that is accessible to all and not only to visually impaired players, regardless of its challenges;
f) Add the One Switch[6] option for people with reduced or very-reduced mobility;
g) Reformulate mainstream games in different genres to make them accessible concerning various types of disabilities.

During the session we also received suggestions regarding audio:

a) Sounds that enhance the players' current environment in the game should be prioritized, e.g. a clock noise or a door opening behind the player may contribute to a more accurate perception of the scenario;
b) Audio feedback for the players should be improved, e.g. hitting an obstacle, sound of steps while walking, sound from the back to signal that something is approaching;
c) Echo to enhance perception of distance should be implemented;
d) A narration assistant that reports what is happening in the environment around the character could be implemented.

During the co-design sessions, all visually impaired participants reported that there is a large absence of inclusive games that can be equally played by visual impaired players and sighted people. According to them, audio games or games that use audio as a central resource are part of niche communities, making it challenging for them to reach out or integrate those communities. They also stated that featuring more attractive graphics in these types of games could be an incentive for other players to appreciate and play them.

4.2 Phase 2, Test 1: Results regarding navigation efficiency

The following points were highlighted regarding navigation efficiency:

- The alterations to the sound to create the game environment were effective;

[6] A device that allows people to control a computer or games console using one or more standard plug-in switches. For more information on *One Switch Games*, visit: https://www.oneswitch.org.uk/art.php?id=54 (last accessed 2020/12/22).

- The spatialization of sounds works well, specifically when participants had to change direction;
- The tutorial is useful but may depend on one's hearing memory;
- The problem with audio speed sparked the idea that we could use speed as a difficulty metric – e.g. easy, medium, and advanced.

The route has eight main points to surpass. With those into consideration, we created the following metrics to evaluate of success of players in navigating efficiently:

- Success in 10% to 30% of the path (8 to 6 errors) – Low accuracy
- Success in 60% of the path (5 to 3 errors) – Intermediate accuracy
- 90% success (2 to 1 errors) – High accuracy
- Success at 100% (0 errors) – Level of excellence, without errors

Resorting to these metrics it was possible to evaluate difficulty in navigating by comparing the original path with that traversed by the players, represented in Figure 2.

Participants showed little difficulty when executing the test, after the aforementioned few adaptations. The result of their paths was very close to the designed maze, meaning that the implementation of a training tutorial brought benefits and made navigation more effective. The results are listed in Table 4.

Table 4. Test results

Participants	First Test	Second Test
P1	60% of the way completed (5 to 3 errors) Intermediate accuracy	90% of the way completed (2 to 1 errors) High accuracy
P2	90% of the way completed (2 to 1 errors) High accuracy	90% of the way completed (2 to 1 errors) High accuracy
P3	—	90% of the way completed (2 to 1 errors) High accuracy

4.3 Phase 2, Test 2: Results regarding audio efficiency

Participants highlighted the following main points regarding audio efficiency:

- *Review of the sounds present in the game:* Participants pointed out a dissonance in the sounds of *token collection* and *enemy attack*, stating that these don't seem to match to the corresponding actions. The *token collected* sound wasn't gratifying and the *enemy attack* sound wasn't threatening enough;
- A *level zero/tutorial* was conceived in order for the player to understand the game's mechanics and to associate the sounds of each action with their correct meaning;
- *Refine the use of sound effects*. The sound should follow the mouse pointer giving feedback about the position of the cursor, with a sonic affordance capable of indicating the path to follow or the proximity to an enemy;
- Make adjustments to the narration and make it slower and more perceptible to the user;
- Implement other sensory effects in the game in order to enhance feedback through different modalities e.g. the touch in the perception of textures and temperature.

5. Conclusions and Future Work

Bringing the design process closer to real users, identifying real problems with the help of the people who effectively face these challenges and have a comprehensive knowledge of the difficulties to overcome is fundamental to conceive artifacts that are able to adapt to users. With *MacGuffin*, we re-imagined the classic *Pac-Man* (1980) and proposed an approach that allows us to explore how to overcome limitations faced by visually impaired players. Co-design sessions, interviews, and viability tests of the game prototypes were decisive steps that enabled us to design a maze that sets visual and visually impaired players at the same level.

We can conclude that it is possible to adapt game games like *Pac-Man* resorting to Universal Design methodologies. It is, however, still early to make this statement for other types of games, as this was a small and constrained study. To validate this idea for more types of games means to resort to a larger user sample and execute more and more varied tests over an extended period of time, in search of more robust and varied data and feedback.

For future work, we are aiming to create a prototype device capable of emitting temperatures, colors (within the accessibility spectrum), emit symbols associated with those colors, customizable sound, voice, motion sensors, and able to be connected to a smartphone. The idea is to add an extra layer of sensibility to the user experience which the smartphone by itself cannot provide.

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Borderline

Games and Activism

Sofia S. Santos

Interactive Technologies Institute/LARSyS
Fine Arts Faculty/Lisbon University
sofia.fls.santos@gmail.com

Patricia Gouveia

Interactive Technologies Institute/LARSyS
Fine Arts Faculty/Lisbon University
p.gouveia@belasartes.ulisboa.pt

Abstract. This article explores digital games as media through which activism exists. We highlight several works, which in parallel with certain games, show that authors are working on themes of social and political matters. We review the role of game designer Will Wright, and his creation of games like *The Sims* (EA, 2000_) and *Spore* (EA, 2008). It is also shown, in association with these games, the concept of *mods* and their role in creating communities based on identical beliefs and also enhancing the skills of the player. In this paper we will analyze activism in gaming experiences, serious games, and LGBT inclusion in playful environments. Finally, we present a game named *borderline*, which aims to bring up our main research question: can an interactive experience contribute to generate awareness about social issues?

Keywords: Games, Activism, *Mods*, *Serious Games*.

1 Activism in Games

Through art, activism has been present in various forms, from performance to games, on which we will focus. The game, increasingly accessible, is a medium with the potential to change the way we think. Unlike in music or painting, it establishes an indispensable interaction between the player and the author. This way it is easier for the artists to transfer their ideas to the community.

Authors like Mary Flanagan and Anna Anthropy, among others, are responsible for bringing to attention both the problems and strengths of the gaming culture. There are still misconceptions about games and the gaming community, not only from the media and people outside of it but also from gamers and creators of content (Lima & Gouveia, 2020). Once the public dismisses these myths, it will be possible to acknowledge the strengths of the medium. One of these promising strengths, and subtheme of this article,

is the activist game, distinguished from others by focusing on social, educational, intervention (Flanagan, 2009), economic and environmental issues.

Within these games, we will further look into some AAA games that are creating socially conscious experiences, indie games that focus especially on serious topics, and others, that in some way, create on the player moments of reflection.

2 Projection of Experiences in Games

Gaming as a leisure activity has become more prompt and complex. This means that its demand is also higher. There is thus a need to increase the diversity of games to respond to different types of players, who seek experiences with which they can relate.

The gaming industry has been consistently using while creating content, the same formula that is mostly aimed at the same audience, leaving little space for other artists, ideas, and players. It is, nonetheless, in its majority, a system made by men and for men (Anthropy, 2012).

An immediate response to the lack of diversity in games, that hadn't the intention to revolutionize the industry in sensitizing communities to inclusion, is evident in the worlds of Will Wright in *The Sims* (2000_), *SimCity* (1989), and *Spore* (2008). With these, the player does more than play the game (Gee & Hayes, 2010). Wright gave his players a chance to create the contents of their world and thus create their narratives.

In *The Sims* games, the player is invited to create their characters and build the elements of their life: such as their family, relationships, jobs, and hobbies. In the game *Spore*, there is an identical dynamic, applied to a different narrative. The player starts by incorporating a cell that evolves over several phases to become an intelligent being capable of mastering technology and space travel. During the various stages, the player can change its creature; when it starts inventing things, the player has tools that allows them to create unique vehicles and structures. With these dynamics, the player is no longer a spectator of the narratives produced by others (Gee & Hayes, 2010) and starts creating its own, based on individual experiences (Gouveia, 2009).

3 *Mods* and the Creation of Renewed Narratives with Games

Mods (modifications) can be mere visual additions or alterations to a game, with no immediate changes in behaviors, but they can also change the intentions and playability of a game.

In 2015, Brent Watanabe developed a *mod* for the game *Grand Theft Auto V* (Rockstar Games, 2013), in which he created a deer with free will (Watanabe, 2015). This results in an abnormal experience to the game narrative we are used to seeing.

Fig. 1. Screen captures of the prototype of *San Andreas Streaming Deer Cam* by Brent Watanabe.

Based on the same game, Joseph DeLappe creates the mod *Elegy* (2018-19) that replicates, in the game, the homicides that took place in the USA during the space of a year; DeLappe changes this narrative to a form of political criticism (DeLappe, 2018).

In 2002, for the game *Counter-Strike* (Valve, 2000), Anne-Marie Schleiner created *Velvet-Strike:* a set of sprays meant to be used as graffiti in the game scenario. This project emerged after the 9/11 terrorist attack, following other mods that incited discrimination and violence, already so realistic in games of the genre. The artist created a movement to remember and spread tolerance within the *Counter-Strike* players (Schleiner, 2002).

Fig. 2. A *Velvet-Strike* graffiti in *Counter-Strike.*

In *The Sims*, this possibility for the player to create content transcends the game platform itself. For all versions, there are content-sharing websites created by fans. On the official website of *The Sims 2*, in less than four months, about 125 000 characters and customized houses were uploaded; nearly 5 million visitors then downloaded these. (Business Wire, 2005 cited in Flanagan, 2009). A solid community of people with entirely different backgrounds has been created around something that all had in common

(Gee & Hayes, 2010). In addition to sharing experiences, these communities generate more than that; people acquire social skills when dealing with others with different mindsets (Gouveia, 2009). As well as social skills, inherent in sharing and communicating, creating this type of content requires the player to acquire mastery of tools that may be useful in the real world (Gee & Hayes, 2010).

In addition to the freedom in creating narratives present in *The Sims, SimCity*, and *Spore*, there are more details of these games that deserve our attention. Something familiar to all is the complexity of the systems; there is a dynamic that makes the player plan ahead, something that was not common in video games to date. This forces the player to think about the future and the consequences of its actions. A spirit of responsibility and balance is created, which, transported to the real world, might be useful.

4 The Progress of the LGBT Presence

Concerning judgment building in the players, something EA Games has done with *The Sims*, under pressure from its fan base (or not only), is to have created a space for players to express their sexuality without restrictions. In each series, there were improvements, showing an understanding of the need for social evolution over the years. In the first *The Sims* (2000), there was a chance of romantic interaction between *Sims* of the same sex, but there was no chance of a formal marriage proposal. In *The Sims 2* (2004), this possibility of marriage is created, but with different terms for homosexual or heterosexual couples (Joined Union/ Marriage). In *The Sims 3* (2009) there is no longer a differentiation of terms. Finally, in *The Sims 4* (2014), the previous nomenclatures are kept, and the option to change genders is created. This evolution in a cult game like *The Sims* has the potential to shape a generation of players.

Either way, implementing diversity in characters can be more complicated than it appears. When creating a character, the designer tends to use stereotypes (overly sexualized women, heroes with big muscles, etc.) (Cage, 2007 cited in Shaw, 2009) as a way of creating desirable and recognizable personas. Few characters that are part of the LGBT community refrain from fitting any stereotype. One of the scarce examples can be seen in *Assassins Creed: Brotherhood* (Ubisoft, 2010), set in Rome c.a. 1499, where we play with Ezio Auditore, who, in some circumstances, visits Leonardo da Vinci. In dialogue, he says, for example, "women provide little distraction" suggesting, based on similar historical assumptions, his homosexuality. As in this example, many of the LGBT characters present in games are only secondary to the narrative and, on rare occasions, the protagonist. The solution, however, cannot be to force the normalization of the insertion of the LGBT community into gaming environments as this may diminish what is being attempted to communicate (Woods, 2007 cited in Shaw, 2009).

Creating a game about LGBT matters can fall into a dialogue that will eventually turn what should be common into something outside the norm (Shaw, 2009). Nevertheless, some games do it harmoniously. An example that managed to balance these factors was *The Last of Us: Left Behind* (Naughty Dog, 2014), which closely follows Ellie, a queer girl in a post-apocalyptic environment. This is a game that features a realistic

representation of female characters in their adolescence within an atmosphere of survival and horror. Another relevant game is *Gone Home* (The Fullbright Company, 2013) that sets the player in the position of Katie, a teenager who returns home to find it empty and is compelled to explore and find out what happened. Part of the narrative revolves around her sister Sam who, through various hints, narrates the story of how she fell in love with a girl and the impact the lack of her parents' support had on her life. This game creates an experience of tension and immersion in a narrative that is still necessary for the gaming industry.

5 Games, Activism and *Hacktivism*

In addition to the examples mentioned, in which activism can be present on a casual basis, there are several games whose intentions are more apparent. One of these is Lucas Pope's 2013 game, *Papers, Please!*. The player takes on the role of an immigration inspector from the fictional country *Arstotzka* who, at the end of the war, is in charge of letting (or not) several characters into the country; among these, we see contraband, spies, and terrorists. The player has to balance the subsistence of themselves and their family, and the sense of responsibility and exhaustive control of the border, having to make decisions in a system against time, which calls into question his instincts and reactions.

Another example of activism in a game is *Bury me, my Love* (The Pixel Hunt, 2017), which follows Nour's story and her experience in trying to leave Syria and go to Europe. The player has a passive and potentially decisive role, taking the place of her husband, Majd. The latter has to stay in Syria and replies to text messages giving advice or just keeping company to his wife by exchanging emojis or photos. The game provides a notion of the passing time, showing the complexity of the current emigration situation. Both these games address relevant issues of the contemporary political paradigm, which convey to those who play it, at least, a feeling of empathy capable of changing opinions and generating actions.

With a more comical approach, *The McDonald's Video Game* (Molleindustria, 2006) is highlighted. It is, in short, a satire on the company's practices showing its dark side. In the game, we are responsible for agriculture, slaughter, restaurant service, and business and marketing decisions. With the role of CEO, the player can decide to plant genetically modified grain, destroy protected forests for planting, bribe unions, etc., to benefit the company. Although *Molleindustria* intended to draw attention to the unethical nature of many McDonald's practices, it ended up showing the difficulty that exists in creating a successful fast-food chain, offering almost a feeling of sympathy to the company by the players.

Thinking about activism in digital environments leads us inevitably to the term *Hacktivism*, the use of hacking techniques to create forms of protest (Jordan & Taylor, 2004), with which some of the works already mentioned converge. An example of this is the *etoy* campaign. In 1999, a toy brand whose domain was *www.etoys.com*, upon discovering the existence of *www.etoy.com*, a website dedicated to artistic interventions, decided to buy the latter to stop having it as a competitor. In response, several

online and offline movements have emerged. They created websites to parody the toy brand, sent e-mails to employees informing them of the company's actions, and created a chat-room type platform with graphics of lego soldiers where boycott actions were coordinated. This led the toy brand to end up not buying the domain *www.etoy.com* and suffer a drop in the value of the shares close to 70% (Jordan & Taylor, 2004, pp.83-84).

6 Serious Games

Serious games are games with an agenda. They often correlate with activism for exposing compelling narratives and tend to serve a primary purpose other than entertainment: focusing on teaching, health, marketing, among others.

Inherent to this classification, we could consider game-based learning (or gamification), that is still underused, due to some of the previously mentioned mis-concepts on video game history (Gouveia, 2015). The idea of *levels* and *rewards*, which is a common one in games, is being used as an incentive for workers and students to complete everyday tasks. Game-based learning is grounded on the belief that interaction and experience potentiates learning; this is, when a student can enjoy the process of education it is more likely to absorb information.

Moreover, there is the *games for change* category. According to Flanagan these appear close to the activist theme including matters of poverty, racism, discrimination, war, and human rights (2009). A good example of this is Anna Anthropy's 2012 game *Dys4ria*[1], an autobiographical piece about her experience as a trans woman undergoing hormone replacement therapy. The game tackles personal and social issues as well as financial and medical barriers. Additionally, focusing on feminist ideas, Nina Freeman is the author of several games that, from a child's perspective, confront abandonment issues (*Space Dad*, 2014), eating disorders (*My House My Rules*, 2013), dysfunctional families (*A Pretty Ornament I Made*, 2011), and many others. Not only do games like this help sensitize the public about topics they're unaware of, but also helping those who face similar narratives.

Fig. 3. Screenshot of *Space Dad* (2014), Nina Freeman's game based on a child's idea that her dad was saving the universe, trying to rationalize his absence.

[1] We reference an unofficial website since the original (https://www.newgrounds.com/portal/view/591565) is no longer available to play.

The main goal of this game category is to create an entertaining experience, and at the same time communicate a social message (Swain, 2007). With this in mind, many of these games tend to dissipate the *serious* factor since a large part of the gaming community is not attracted by the *didactic* element of games (Flanagan, 2009).

Several examples mentioned before are in line with the idea of *teaching* without having the player noticing it. The saga *The Sims* and *Spore*, teach long-term planning. *Zoo Tycoon 2* (2004), in which the player is in charge of creating and managing a zoo, passively teaches habitats, food, and habits of the various animals, and part of the business plan itself. Moreover, the *Assassins Creed* saga serves almost as a history museum: in *Brotherhood* (2010), the player explores ancient Rome and can walk through the *Coliseum* mimicking real-life experiences; *Origins* (2017) is set in Egypt and *Valhalla* (coming out in 2020/21), during the Viking empire. All of these games are conveying knowledge to the player without the educational feel to it since the fun factor dilutes all the information presented.

Fig. 4. The Roman Coliseum in *Assassins Creed: Brotherhood* (2010).

Some of these games may simulate real situations creating a space for the player to experiment and fail, without consequences. The act of producing anxiety in the player can simultaneously give them a feeling of satisfaction if they are in control of the situation (Flanagan, 2009); this is valid for social aspects, for the completion of certain tasks, and even in the mastery of physical activities.

Due to this, many artists have used this medium to create instructions that will generate actions on the part of the players (Flanagan, 2009). Through games, it is possible to educate people about political and social issues, eventually creating a society with better decision-making power.

Mary Flanagan states that the patterns of games reflect cultural changes (2009, p.24), and this statement can be opened to vice versa, admitting that culture is also moldable by games. The *Pokemon Go* augmented reality mobile app (Niantic, 2016) has become a phenomenon that was the focus of several media broadcasts. It took many members of the gamer community to the streets, changing their habits, and positively impacting their health. In 2018, a similar phenomenon was observed with the game *Fortnite* (Epic Games, 2017); it did not have such a positive impact as *Pokemon Go*, nor the media acclaimed it, but its cultural impact is undeniable. It has overwhelmed platforms like Twitch and Youtube, and some of its content like flossing, dab, etc. (which have its

own controversies) passed onto the real world and was seen in schools, parties, and the vastness of social media. The path to success for serious games and activist games is about creating an environment in which the player feels comfortable playing (Flanagan, 2009). That said, there has to be a balance, made by game designers, to capture the interest of the players without compromising their thought process.

7 Borderline

We perceived in previous sections that games have the power to convey narratives in a way that differs from other media since it creates an essential interaction between the player and the creator. This interaction is ideal for giving the user a role in something; giving them responsibilities in an environment without consequences for the players to question their choices and have the chance to repeat the journey.

Intending to merge the topics studied and using this potential of the medium, we created *borderline*. Alike *Dys4ia* (Anna Anthropy, 2012), *borderline* regards social and personal issues reflecting thoughts of anxiety and overthinking. Another project that, to a certain extent, resembles ours is *SuperBetter*, Jane McGonigal's 2012 *alternate reality game* intended to make a positive impact on the player's habits and mental health. These contrast in a way where *borderline* aims to put the player in an introspective state of doubt and concern, instead of creating an environment in real life to reduce these thoughts.

Fig. 5. Screenshot of Anna Anthropy's game *Dys4ia.*

At a conceptual level, *borderline* arised from the need to, in a time of pandemic and confinement, communicate the frustration of breaking routines and expectations of the self, and others. The experience given by the game is also an approximation to the homonymous mental illness that is characterized by having an impact on the way of thinking about oneself and those around; it can create difficulties in dealing with emotions and engaging in relationships, leading to emotional crises. It also reveals itself in the form of extreme fear of abandonment, acts of self-harm, chronic feelings of emptiness, a tendency to hold grudges, etc. (World Health Organization, 1993). One in all, the game is an invitation to enter a wandering mind where the player will be able to explore and be immersed in thoughts they had forgotten, never had, or were repressing.

Through a different point of view *borderline* falls into the art game category, alongside *Everything* (David O'Reilly, 2017) and *Proteus* (Ed Key & David Kanaga, 2013), which main objective is exploration; there is no chance of winning or losing, just finishing and starting over, collecting memories.

Fig. 6. Introduction of *borderline*

During the experience, the player gains control of the character, a white cube on a black background where various messages and animations are displayed. The messages can be unexpected, insecure, inquisitive, and uncomfortable questions or statements, taking the player on an introspective journey. These serve, optimally, to those who read them as an incentive to, once again, review their memories, create new ones, or, at least, generate some unusual emotions.

Fig. 7. Scenes of *borderline*

Throughout, when deviating from its path, the player encounters an environment filled with color and *odd* animations. Each one encountered becomes part of the player's story and is collected as a memory.

Fig. 8. Menu of the collected memories

When opening the game, the soundtrack begins. It consists of three sections: the introduction that only appears at the beginning and is then followed by four measures that repeat on a loop until the player reaches the end, where all dissonances and discomfort are resolved with the final sentence.

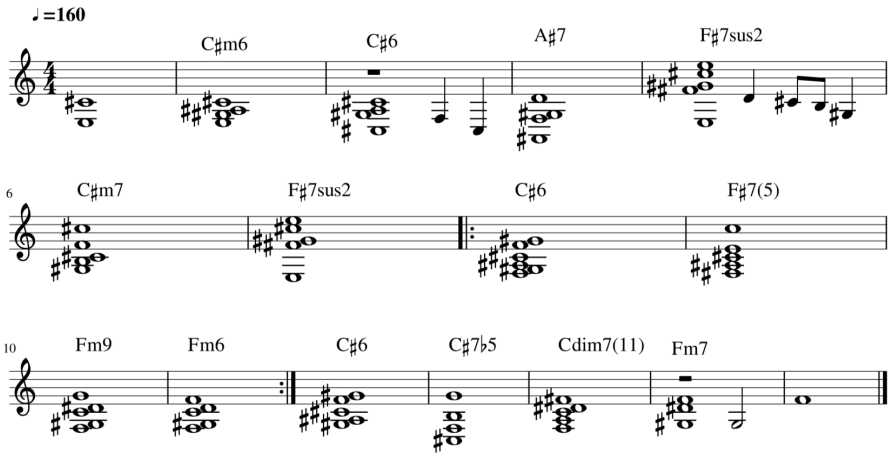

Fig. 9. Simplified chord progression

The harmony used is embellished with ninth chords denoting tension through dissonances, sixth chords that create points for resolution, and seventh chords that destabilize the chord and offer a way forward. The complex harmony and repetition end up causing the player to feel uncomfortable and uneasy.

Fig. 10. Final scene of *borderline*

In *borderline* there is a correlation with life in which, whatever the path, there is an invariable finale. A literal atmosphere is created around the cliché of *giving value to the journey and not the destination.*

8 Conclusion

The *borderline* playful media was designed with an exploratory research question, can an interactive gaming experience contribute to generate awareness about mental disorders? In that scope, we used an exploratory research methodology with the aim of reflecting on the borderline mental and behavioral disorder to make the player feel empathy about the troubling condition of those who have it. Previous research in playful media and gaming was done with the goal of connecting media studies and game design with an activist and artistical perspective. The prototype created suggests an introspective journey through music and visuals with a poetical arts-based research approach where the players fill the voids of interpretation with their own ambiguities. Future research in gaming applied to behavioral disorders, such as anxiety, will be supported under a master thesis at the Lisbon University Fine Arts Faculty and the research center ITI/LARSyS.

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Ollie's Escape

João Sernadela[1] and Rui Pedro Lopes[1]

[1] Polytechnic Institute of Bragança, Bragança, Portugal
jsernadela@gmail.com, rlopes@ipb.pt

Abstract. Nowadays, the gaming industry it's a major economic sector with a large monetary worth and exponential world demand. Regarding such, one of the eminent causes to this fact is, without a doubt, the entertainment that games can provide to different people of different age groups. However, with high demand and variety of games already in place on the market, it is becoming more and more difficult to design something that differs and highlights from mainstream games. For that to happen, innovation and creativity are required, given the target audience. Thus, in this article, it is intended to describe in detail the development process of Ollie's Escape, an animated 3-dimensional game (3D) inserted in the thematic of "escape game", made in Unreal Engine 4 (UE4). So, described in this article are the results of all the relevant aspects associated to the development of the project, such as: creation, modelling and animation of characters and objects, level design and programming in UE4's Blueprints, as well as the implementation of all the features carried out. The final results were quite satisfactory, where all the proposed objectives were accomplished, attaining a positive feedback.

Keywords: Escape game, Ollie's Escape, 3-dimensional, Unreal Engine 4.

1 Introduction

The evolution of digital games was an expected consequence of the development and improvement of computers (Wolf 2008). Nowadays, the gaming industry is growing, with a demand by players all over the world. In this way, there are currently several games that can appeal to any age group, with an extensive diversity of genres: Role-Playing Game (RPG), strategy, animated, adventure, action and many others (Wolf 2002). The evolution of video games also met the evolution of gaming platforms, such as consoles, computers, tablets and smartphones (Silva and El Saddik 2013; Host et al. 2016; Lindqvist et al. 2011). These devices provided users with access to a vast amount of resources and media, for learning, relaxing, entertaining and playing. Regarding the latter, this paper describes the entire process of creating and developing a 3D game, of the escape game type, named Ollie's Escape. A systematic design approach was used, based on the book "Game Design: theory & practice" (Rouse 2005). The game was developed in Unreal Engine 4, by Epic Games, and Blender, to create the 3D objects and respective animations. Lastly, for the implementation of the game, it was decided to resort to blueprints.

2 Ollie’s Escape

Ollie’s Escape is an escape game, in which the character has to find a way out of an enclosing space by finding clues and solving puzzles. After succeeding within a predetermined time limit, he will be able to escape the room (Dietrich 2018).

2.1 Narrative

The narrative of the game is based on a simple and animated story, where Ollie, a boy's favourite robot toy, emerges as the main character. Ollie is left alone at home while the child (Wade) goes on vacation with his parents and, due to an electric storm, the little robot gains a life of its own. He will then start to look for Sybil, his female robot friend, in an attempt to bring her also to life. For this, Ollie will have to explore the house where he is, complete various challenges and puzzles and collect coins and objects, so that he can reach Sybil, in the neighbouring house. In this way, the game fits into the adventure games type, with the theme of “escape”, where the player will have to collect items and complete several puzzles in order to be able to escape from the place where he is currently.

2.2 Characters and Objects

During the game three characters appear: Ollie, Sybil and Felix, the cat. The main character is Ollie while the remaining characters secondary characters (Sybil only appears in the game's cinematics). Ollie is a robot toy whose armour is painted red and dark grey. He has a helmet with glasses. Sybil is a robot identical to Ollie, although her armour is pink, and, in her chest, there is a heart instead of a circle. Felix appears as a secondary character at one specific moment in the game. The colour of its eyes is green, and its hair is dark grey, having several light grey stripes all over his body. In order to make the environment more creative, it was decided to carry out the creation of several objects in Blender that could appear on the scene during the game. Thus, once the adventure starts in the family’s house, and the environment appears as animated, all objects must be simple and appropriate to this world. Given this fact, one of the main requirements for objects is the existence of a lot of diversity of colours, patterns and textures.

2.3 Animations

After the main character was created, it was necessary to carry out his six animations:

- **Idle** - occurs when the robot is stopped in the same place, consisting in a paused circular animation;
- **Run** - when the player presses the keys to move to the various directions;

— **Jump** - when the player presses the space bar to reach an altitude higher than the present;
— **Open doors and drawers** - when the player presses the key to open a certain door or drawer. It consists in a circular path to a position behind, to the player don't collide with the door or drawer that will open;
— **Mechanical Punch** - When the robot ejects his hand (fist) into his current direction;
— **Sit on the cat** - an inactive and paused animation while the robot is mounted on the cat.

For the cat, it was also necessary to carry out the base animations such as: idle, run and jump.

2.4 Level Planning

In order to organize the objects in the scene, a plan was made for each step of the game with the disposition of all the objects. The step one occurs in the child's bedroom (Fig. 1).

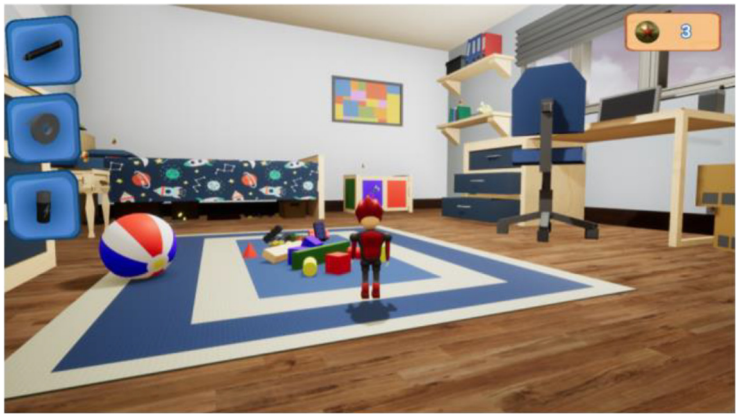

Fig. 1. Representation of the First Level

Thus, it was thought of all the objects that could be part of this phase and it was decided to make a plant of the bedroom, as shown in Fig. 2. The level two adventure takes place in the living room of the house, which is shared with the kitchen. The third and last level is outside the house, where there will have a small terrace and a garden at the front.

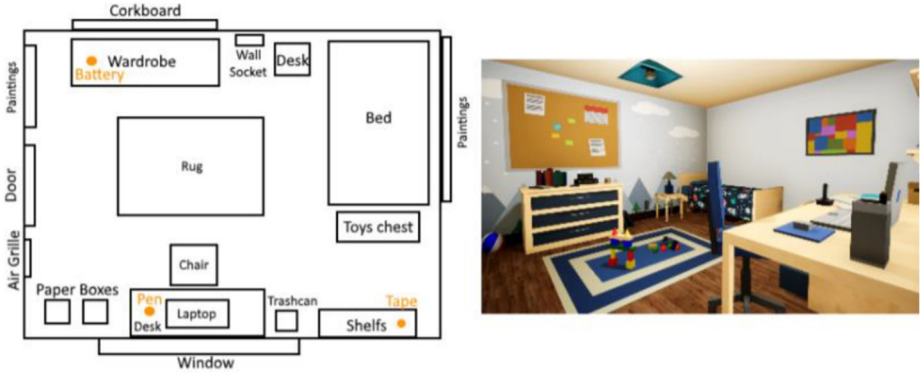

Fig. 2. Representation of the First Level

2.5 Special Abilities of the Main Character

In order to complete certain parts of the levels, the player will have to resort to using the special abilities that the little robot Ollie has. Thus, depending on the stage, the skills to be used can be divided into two mechanisms:

Mechanical Punch - applied at level 1 to break the room's air grille to pass to the second level, this ability consists of ejecting the robot's fist to forward.

Grapple Hook - appears on level 2, when the robot has to collect the wool ball that is on the top of the fireplace. Thus, this ability rests on a rope that is projected through the player's position and pulls Ollie to the point marked.

2.6 Planning of the Puzzles

In the first stage of the game, when the player approaches the laptop computer that is on the desk, he must complete a game in which Ollie is lost in a maze and will have to get out of there as fast as he can. In this maze, the player can collect coins and must reach the portal, to be transported back to the child's room (Fig. 3).

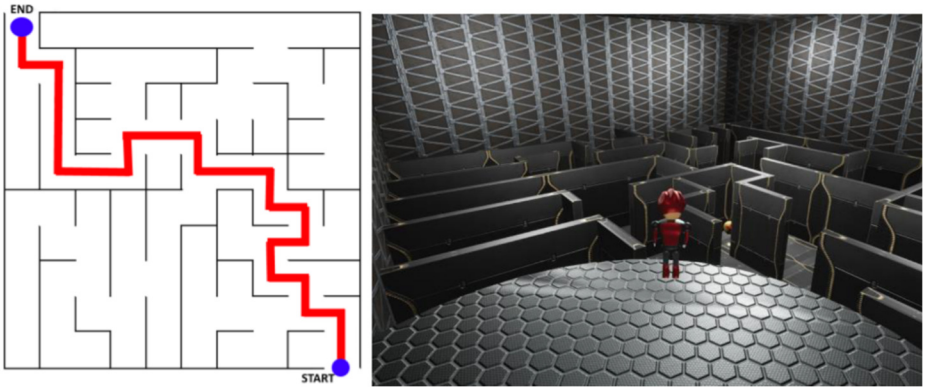

Fig. 3. Maze Solution

On the other hand, on the third and last level, a cat will appear on the terrace and Ollie will have to mount on it, changing the game mode to "runner game", where the player will control the movement of the cat and will have to step aside from the obstacles that are in the way. In this game, the small robot has three lives and each time it hits an obstacle, it is deducted the number of lives corresponding to it (Table 1). If the player runs out of life, he will have to start all over again.

Table 1. Number of lives discounted per obstacle

Obstacle	-1 Life	-3 Lifes
Bush	X	
Tree	X	
Flowers	X	
Bridge Hole		X
Rock	X	
Watering Can	X	
Mower		X
Border (Frontal Hit)		X

2.7 In-Game Features

Camera zoom - so that the player can observe better the details of the objects and the main character a system to control the proximity of the three-dimensional camera was implemented. Thus, the player can, with the help of the mouse wheel, approach the camera and return to the initial position whenever he wishes.

Collect items - the entirety of the game is directed to the player having to collect the items in the scene. Therefore, when controlled by the player, the robot can hit various objects, and these will be instantly picked up, removing them from the original position and adding them to the inventory.

Double jump - the number of jumps has been restricted to one to increase the difficulty. However, it was decided to let the player perform a double jump in the following two situations: in the first level when the player has jump twice on the ball to collect the battery and in the last stage of the game (runner level) when the player can pick up a bonus that allows him to double jump for five seconds.

Drag objects - at some phases of the game, the player can get closer to objects and move them on the xy coordinate axis.

Code to unlock door - When the player is at the end of the second stage of the game, he has to figure out the code to open the door to reach the next level. Thus, an interface has been implemented in which the player can write the code and open the door. The solution of the correct four-digit combination (1200) can be seen in the picture frames in the hall compartment and can be seen from the glazed door.

Save and load game - in order to retain the progress of the player, a save and load game functionality has been implemented. Thus, during the levels, the player can open the menu and save their progress (items and coins collected). Once the game is loaded, all coins and items already picked up will disappear from the scene, making it impossible for the player to collect more coins or items than the level allows.

Store and inventory - the player can access, through the menu, to the game store. It is in there that the player can buy items, solutions and special abilities with the coins collected during the game. In this shop, the player will only be able to buy the items referring to the current level. Once the player is in the main menu of the game, you can access the interface “load game”, where you can see a list of objects already collected (inventory).

Settings - whether the player is inside a level or in the main menu, he can access to a graphics and audio settings interface. Here the player can change the values and change the game window style to “fullscreen” or “windowed” (Table 2). The volume of the music or effects of the game can also be changed in this interface through a slider, followed by a button that disables or enables the sound of the game.

Table 2. Game settings

	0	1	2	3
Graphics Quality	25% (Low)	50% (Medium)	75% (High)	100% Ultra
Post-Processing	Low	Medium	High	Ultra
Anti-Aliasing	Low	Medium	High	Ultra
Shadows Quality	Low	Medium	High	Ultra
Max FPS	15	30	60	144

User Interfaces - in order to provide full control of the game to the player, several graphical interfaces have been made in which the player can click buttons, making something happen. These included in-game menus, animations to make information available to the player, and others.

Cinematics - to shows to the player the game history and to create a more comfortable environment for the game, a total of five cinematics was created during the game: two on the first level, two on the third level and one when the player concludes the game.

Keys used in game - the controls of the game are presented in Table 3.

Table 3. Control Keys

Keys	Functionality
W,A,S and D	Control the robot
Space Bar	Jump
Escape or M	Menu
Alt+C	Cheats Interface
E	Mechanical Punch, open doors / drawers and ride the cat.
Z	Collect Draw
C	First person camera with sight view
F	Follows the grapple hook

3 Results

Once the implementation was finished, a test phase was elaborated in order to obtain the final results of the developed solution. Data was acquired through three instruments, namely visualization through video recording of the players to measure the interaction with the game, field notes to register behaviours and reaction of the players and a questionnaire to get the perception of the players about the game and gameplay. Data was acquired between June 30, 2017 and July 2, 2017 during twenty tests.

During tests, one bug was found, although it did not prevent the game from proceeding. It was promptly corrected for the following tests. Players found the game very interesting and joyful, mainly because of the adopted design and toy theme. The gameplay was found interesting and diversified, with a set of different challenges and puzzles to overcome.

The questionnaire was structured in two parts. The first, composed of yes/no questions, had the purpose of getting the global perception of the game by the player. It had the following questions:

1. Do you like "escape games"?
2. Do you think the game should have more mini-games and puzzles?
3. The on-game instructions and help was sufficient?
4. Did you use the game store in any moment of the game?
5. Was the font size adequate?
6. Did you like the game aesthetics (characters, objects, materials and textures)?
7. Did you think the options menu had enough settings?
8. Did you like the sound effects and background music?
9. Would you play Ollie's Escape in future adventures?

85% of the players (153 yes and 27 no) gave positive answers to all the previous questions. The less voted was 1 and 3.

The second part of the survey was composed of 6 Likert scale questions, to assess the game complexity, aesthetics, design, music, sound effects and narrative. A descriptive statistic was performed (Table 4). From these results, the opinion of the players is mostly positive. However, there are some aspects that can improve, namely increasing complexity and the narrative.

Table 4. Table of results of the quantitative values of the survey

	Complexity	**Graphics**	**Design**	**Music**	**Sound Effects**	**Narrative**
Mean	4.1	4.65	4.6	4.25	4.2	4.15
Mode	4	5	5	5	5	4

4 Conclusion

This project was chosen due to personal interest, not only in the area of games, but also in the part of creating and modelling elements in three dimensions. Thus, for the realization of this game an intense study on these two areas was carried out and many ideas were considered in order to provide an interesting and innovative game. In this way, several related games and technologies were considered necessary for the elaboration of the project, having as main software Blender and Unreal Engine 4. The final result was a simple and pleasant game. The evaluation was performed with three different

instruments, namely video-recording of playing sessions, field notes and quantitative questionnaire. From the evaluation results it is clear that the aesthetics and mechanics were successful, although the complexity and narrative can improve. In addition, it is also important to provide instrumentation of the game, to register the players' actions and further improve the usability and mechanics.

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Built for communication: a strategic perspective of digital games in health

Susana Lamas[1], Nelson Zagalo[2] and Helena Sousa[1]

[1] Centro de Estudos de Comunicação e Sociedade, Instituto de Ciências, Universidade do Minho, Campus de Gualtar, 4710-057 Braga, Portugal
sp.lamas@gmail.com

[2] DigiMedia, Universidade de Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro

Abstract. In *health promotion*, public communication campaigns have been used to promote the adoption of appropriate behaviors, or the prevention/ cessation of health risk behaviors [1]. They are the result of marketing activities by health organizations (including research and government institutions), as part of a strategic communication [2]. Serious games have a relevant role in the media mix used in public communication campaigns [3]. They are seen with such a potential that attract strong public and private investments to their development. But although serious games can take part of campaigns, in reality they have different origins and intentions from this strategy tool, underlined by their own specific theoretical frameworks in game design and game studies. The attraction and engagement they exert on players, make them promising tools for communication and mobilization. Their theoretical undefinition, the extent and diversity of serious games, and the permanent search for new kinds of games, make them flexible tools from a strategic point of view [4-6]. In this paper, by analyzing a sample of Games for Change (G4C) in health (concerning their objectives and effects) when compared to the traditional information/ communication campaigns, we identified expressive differences and advantages in serious games. G4C tend to be less persuasive, more focused on social changes, and embrace different forms of *inbuilt communication*, which bring flexibility in the sense of communication, and player´s participation on it. In concrete, we have identified: interactive, biofeedback, data and ritual/ artistic forms of communication.

Keywords: Strategic communication, Campaigns, Health, Serious games, Participation, Interactivity, Inbuilt communication.

1. Communication campaigns in health promotion

1.1. Communication perspective

Communication campaigns represent the meeting place for different communication approaches, tools and strategies. In health promotion, they join contributions from professionals of communication sciences, education and public health, as part of the activity of institutions or companies, in the sense of sharing relevant information for the

adoption of healthy behaviors, making better use of health systems or preventing risky situations." [7].

Defining a *communication campaign* is not an easy task, since there is a latent diversity within this strategic tool. We can say that they differ from traditional methods of education and communication - such as the dissemination of scientific results through news or health education in public schools - by the use of more persuasive communication strategies [8], often through mass media [9] and following a social marketing approach [1].

Among the different definitions of a communication campaign, that of Rogers and Storey [10] is one of the most cited and still contemporary [1, 11-14]: "A minimal definition of *campaign* would have to state that (1) a campaign intends to generate specific outcomes or effects, (2) in a relatively large number of individuals, (3) usually within a specific period of time and (4) through an organized set of communication activities". The keyword in this definition is in the term "purposive". A communication campaign always seeks to generate specific and measurable results in individuals and populations. As for the target audience, "a relatively large number of individuals" draws a line between the communication campaign and persuasive interpersonal communication, where only one (or a few) individual(s) seeks to influence some others. Campaigns that use at least one form of media are called *media campaigns* [1] and are obviously distinguished from *interpersonal interventions*, that is, interventions based on *face-to-face* or small group communication, including counseling, outreach, and workshops [9]. Despite this, interpersonal interventions can integrate, and be an important part of, the strategies of a communication campaign, as we will see below. Finally, campaigns differ considerably in the particular communication activities they use, which include posters, handouts, public service announcements, discussion groups, workplace or clinic-based counseling, and in-school presentations [1].

In their genesis, health campaigns can be classified in different ways [14], which focus mainly on their objectives and intended effects.

Some types of campaigns follow (or integrate) upstream approaches, focusing on individuals with interpersonal influence (e.g. heads of community institutions or local government) to influence individual behaviors [15]. The selection of objectives and of the target audience of a health campaign is not innocent. For example, a campaign may follow a media advocacy approach, seeking to set health issues on the media's and the public agenda; or follow political approaches, to influence policy makers and laws – it depends on the socio-ecological level at which it is intended.

Some campaigns, called Public Will Campaigns [11], aim at mobilizing public action for policy change, thus focusing less on the individual who is performing the behavior (e.g. the smoker), and more on the public's responsibility to do something that will create a supportive environment for behavior change. They use media advocacy, community organization and mobilization approaches, and act (among other ways) by increasing the visibility and importance of a given subject, influencing perceptions about who is responsible, and involving/ mobilizing voters for action [11].

There are also campaigns that do not seek in any way to inform or persuade, but, for example, to assess the impact of media advocacy efforts on health, on a specific audience or group of journalists [8].

Some media campaigns integrate interpersonal communication approaches in their strategies, which may respond to some lack of effectiveness of mediated interventions in health [9, 16]. As we will see later, one of the critics to traditional information/ communication campaigns [17] (strongly based on mass media) is their linearity, which reduces the socio-cultural sensitivity of the interventions [8]. Rogers and Storey acknowledge the use of interpersonal channels in communication campaigns "(…) for forming, changing and reinforcing attitudes and to mobilize over behavior on a more personal scale" [10]; and also to root health messages in a meaningful social context for the target audience. Examples of this approaches are community-based campaigns, such as the AIDS Community Demonstration Projects [18, 19].

One step further than this instrumental view of interpersonal communication, there are campaigns which integrate the opinions, points of view and priorities of target audiences in their design or evaluation, such as those that comprise community dialogue approaches [20]. There are also campaigns with participatory communication approaches [21], that use interpersonal communication not in a counseling (e.g. doctor-patient), or specialist/ non-specialist, perspective, but for mutual understanding and sharing (as in *Bienvenida Salud!* [22]). Participatory communication is a strategy that opens up opportunities for the voice of minorities (groups with little influence or needy), in a vision of democracy that suggests other forms of participation than voting or political involvement [23]. From a pedagogical perspective, in participation teacher and student learn from and teach to each other, in a mutually transformative process [21]. From the communication perspective, participation is a horizontal process and in a balance of powers between the different actors [23].

Taking into account the diversity of approaches and strategies available in health communication, when defining a campaign's strategy, the choices between *persuasive vs participative*, *top-down vs bottom-up* or *linear vs bidirectional approaches* become important, within the field of study of researchers and communicators. In all these dyads there is an evolution towards a greater cultural sensitivity of the interventions and, quite possibly, a change in the effects of communication (from the individual to society; from individual change to *social change*), and in its objectives (from persuasion to awareness).

1.2. Difficulties of campaigns

Two difficulties have been identified in planning and implementing health communication campaigns. The first is related to the limited effectiveness that communication campaigns and other mediated interventions have shown in changing individuals' behaviors [16]. The second concerns the immeasurable competition for time and space that health messages face in the mass media.

As Greenberg, Salmon, Patel, Beck & Cole [24] highlight, much research on the effects of mass communication in communication-based interventions predates the proliferation of the internet and fiber optic television, with more than 100 channels and captivating services streaming. In addition to an overabundance of health messages in health television channels, fiction and nonfiction medical shows on television, and thousands of health information websites [24], the influence of online communication

networks - through social media, blogs, listservs, emails, or text messagings - is also multiplying [8]. While this does not seem to be yet of concern in many parts of the world, it already poses difficulties in countries like the USA or in Europe. To contend this problem, several voices call for new and engaging communication solutions [5, 8, 9, 25, 26]. There is also a particular call for new interactive formats, that allow tailoring of health messages for specific audiences [8, 25], and the lengthening of interventions in time.

To (try to) tackle the lack of effectiveness of communication campaigns (as already mentioned), several authors argue for interventions with a greater socio-cultural sensitivity [8, 27] or culture-centered approaches [27] of communication. The linear model of communication, most common in traditional communication campaigns, is a transmissive model in which communication moves unidirectionally (from the sender to the receiver), as represented in the *communication influence process* of Dennis McQuail's model [17]. This unidirectionality takes place even in emerging formats of *entertainment-education*. The linearity is broken in communication campaigns whose strategies include interpersonal, network or participatory approaches to communication. In this context, campaigns that include a community approach and qualitative/ interpersonal methodologies are advocated. Namely, those that comprise interpersonal or small group communication; community dialogue; an extensive formative evaluation, as well as qualitative assessments of the campaign's process and impact; or participative approaches, including *participatory community media approaches.* The latter refers to campaigns whereby individuals or members of the community assume the role of producers of (health) intervention messages. In participatory communication, health communication researchers and practitioners have a very different role of that in persuasive campaigns, which involves encouraging participation, stimulating critical thinking, and highlighting/ supporting the transformation process (as opposed to seeking predetermined results). From the above, we can infer that interpersonal communication is the tool that allow points of view, opinions and priorities of members of a community to be responsible for health strategies in the group.

2. Digital games in health promotion

When we analyze the definition of Rogers and Storey [10], we realize that a *serious game* has characteristics that adapt well to a communication campaign:

a) all serious games are "purposive"[28],
b) many serious games can be widely distributed, reaching a large number of individuals;
c) the widespread and pervasive nature of games in many societies - make them appropriate tools for reaching different audiences;
d) their effects are limited to the time in which the game is playable (serious games can also be subject to formative, process design and final impact evaluations).
e) parallel to a game release several communication activities exist (e.g. online reviews, newspaper' articles/ special columns, merchandising, as well as game conventions and competitions.

Thus, in terms of intent and implementation, serious games are not so distant from communication campaigns. But, as advanced below, serious games have a set of distinctive attributes, which make them not only interesting tools for learning [29], but also communication tools with a strong attractive and engaging power, especially for younger people.

2.1. Engagement / entertainment potential

Digital games are media recognized for their enormous potential to engage players. As a reflex, there are numerous studies in the literature that seek to define the concept of *engagement*, in association with concepts such as *Flow*, *Gameflow*, *Presence*, *Immersion*, *Pleasure*, *Motivation*, *Enjoyment* and *Fun* [30]. While, for some authors, engagement seems to be a property of the activity of the game - according to Brown [31], *Play* is a voluntary and spontaneous activity, with no apparent purpose, an inherent attraction and a desire for continuation -, for authors such as Przybylski, Deci, Rigby and Ryan [32-34], video games capture us because they fulfill, in very powerful ways, specific and intrinsic human needs. From the perspective of social change, one characteristic of digital games that is perceived as particularly suitable for supporting empowerment and inclusion is precisely its motivating potential [29] - which leads players to join the game and to desire continue playing.

This power of engagement lies on the unique quality of player's interaction with the game, and is not found in traditional communication formats - such as news or reports, information / awareness websites, radio programs or TV, advertising products or documentaries. Przybylski, Rigby and Ryan [32] had already called interactivity as "mastery of controls". Calvillo-Gámez, Cairns & Cox [35], more recently, add the term *puppetry*, as "how the player starts approaching the video-game until eventually the game being played is the outcome of the actions of the player". In puppetry, *ownership* - the player using the elements of control of the game in his/ her favor, to create his/ her own story – influences the interaction and seems to be the most probable condition for enjoyment. In the *Core Elements of the Gaming Experience* (CEGE) theory, puppetry does not necessarily translate into a positive gaming experience, but is an essential condition for this to happen [35].

According to Andrew Cameron [36], interactivity means "[...] the ability to intervene in a meaningful way within the representation itself, not to read it differently.". In contrast to the interpretation of a game, interactivity allows players to influence the course of the game, its events and story. Of course, the player's activity is limited to what the game designer allows to happen, but today the term encompasses a multiplicity of actions, what ends up widening the range possibilities within this concept [37]. In the concept of *ownership*, the authors [35] describe interactivity as the game's property that allows the player to establish his own *personal goals* within the game, or to engage in actions that would not necessarily do in real life, in an effect called *you-but-not-you*, enhancing the gaming *experience*. As we will see later, interactivity underlies the concept of *participation* in video games according to Raessens [37], along with the media culture that is formed around it.

2.2. Resources for individual change and social transformation

The *transfer* [38] of the player's behavior from the inside out of the game has some theoretical references. Feelings of *immersion* and *presence* in the game can increase or decrease the carryover effects of game content into the real-world [32]. The game's narrative arouses curiosity, involves and generates *transportation* [39-41], as well as supports the retention of information and sensemaking [42, 43]. The identification with characters or avatars [44], can promote an affective connection of the player [45] and a *vicarious* experience [46]. Paul Gee [47] defends the enormous advantage of digital games in learning, introducing the concept of *situated cognition* (i.e., thinking as tied to a body that has experiences in the world, situated within a material, social, and cultural world). In serious games for health promotion, these theories, and others such as *self-efficacy* [48] or *message framing* [49, 50], in addition to *game-based learning*, are integrated in a framework that aims to promote the player' behavior change [51]. Underlying the design of games' messages there are psychology, educational, social and science communication theories, as well as a whole theoretical framework of the areas of game design and game studies, as in drawing *user experience*. These games end up having a *persuasive* aspect, that identifies itself with this strategic approach to communication in health. Some authors even commend games be prescribed to achieve explicit objectives, in an analogy to the prescription of a clinical treatment or medication [52] (even though this assumption seems premature [53], there is already an approved videogame prescription to improve attention function in children [54]). Klimmt [4] raised a theoretical framework for serious games as appropriate tools for social change, assuming a wide definition for this concept that include changes at the individual cognition and behavior. Klimmt's theoretical matrix rely on well-established psychological mechanisms - related to exposure and elaboration motivation, to comprehension and knowledge acquisition, and to persuasion and attitude change -, to join arguments for serious games closer to those of entertainment education media.

Under the persuasive trait of serious games, there are games that don´t rely on a cogent psychological framework to instill behavior changes in players, but use *procedural rhetoric* [55] to produce critical reflection of processes in society, informal discourse, and changes of minds. Although being persuasive (they are, indeed, called *persuasive games*), they don't expect to produce immediate results but seek long-term social transformation; and can be used, in a strategic perspective, for civic outreach to support participative approaches to communication. *Persuasive games*, as defined by Ian Bogost, distinguish themselves from digital games of the *Serious Games Initiative*[1] by not taking on institutional goals, or supporting existing social and cultural positions, but be willing to disrupt and change "fundamental attitudes and beliefs about the world".

Digital games can thus be supportive of participative approaches to communication. The European Commission's *Joint Research Centre* (JRC) [29] specifically identifies three approaches to the empowerment and social inclusion of individuals, through

[1] In this paper, we use a wider definition of *serious games,* as conceived by Gonzalo Frasca (2007) – "games that aim to communicate in addition than entertaining" or *games with an agenda*-, and later endorsed by Mitgutsch and Alvarado (2012) as *purposeful games.*

games: (1) special-purpose digital games; (2) learning and participation in (and surrounding) well-designed *commercial off-the-shelf* digital games (COTS); and (3) the co-creation of games. In the first approach, serious games are means to knowledge transfer, skill acquisition, or attitudinal & behavior change, reinforcing skills in players that facilitate their inclusion and empowerment. Apart from formal literacy skills, there are also examples of games that introduce players to civic participation, reinforcing citizenship skills [56] and raising awareness to relevant social problems, in order to mobilize for social change [57].

Games for Change (G4C) and *Serious Games Initiative* [58] have broken down the spectrum of solutions they envisage in digital games, as tools for organizations in social change, along three functional axes:

a) games as practical tools for civic outreach – e.g. through fundraising, mobilizing constituencies, and raising awareness;
b) games as environments for civic learning – by providing players direct experiences and immersive learning;
c) and games as social actors in forming civic identities - by creating relationships, such as in e-mentoring and networked learning.

2.3. Digital games as spaces for communication: the player as a participant

There are also games that, beyond supporting participative approaches to communication, instill the player to have an active role in the communication. The most obvious form of an individual's participation in a game is co-creation. As identified by the JRC, co-creation is a process of learning and participating through the creation and adaptation of digital games, identified with the participatory community media approach to communication. It uses free or low-cost tools and platforms (that enable people, without programming knowledge, to create digital games and to share them) as resources, or even certain digital games that come with the functionality for modifying them. In this context, the co-creation of games "help those at risk (…) to increase their sense of agency, to explore their creativity, to build digital literacy skills and to ensure their voices and needs are heard" [29]. Another way of giving individuals a voice, in the design of digital games, is the use of qualitative methodologies in the game design assessment (formative and other) [59]. Notwithstanding, despite its indisputable relevance in serious game design, it does not put the player in the role of communicator (but the games' target audience), not adding to the present discussion.

As we saw earlier, inherent to digital games is the unique quality of interactivity, encouraging the player's ownership or appropriation of the game [35]. When a player intervenes in the game by establishing his own personal goals - for example when, in an online game, he sets a goal to help other players, or takes the option of allying himself with good or evil, in the course of the game [35] -, or deluding (and testing) himself in fictional representations that goes outside his reality, he is changing the meaning of the game for himself, and therefore, intervening in communication, which is a form of participation according to Raessen [37].

In addition to this interactivity, a significant part of the games, currently, includes important social components [29], that deepen the participation of the player in the game. Complementing the possibility of becoming part of a community of practice, many games today lead the players beyond the individual experience, to a social one, making them feel part of something bigger [57]. Massive Multiplayer Online games (MMO) promote this social aspect par excellence by facilitating spontaneous collaboration and the formation of social networks, within the game itself. All this production or activity of the player (including forms of modification of the game play available to the players with programming knowledge), align with the concept of participatory culture introduced by Jenkins [60].

In another perspective, we can foresee another form of participation in the game, which concerns the communication established between the designers/ communicators and the players, or in this case between the machine and humans. In essence, we refer to games that accept a second direction in communication, of which the most evident examples are the still rare games designed using artificial intelligence systems (such as *procedural content generation*, or specifically for *authoring playable social models* [61]). But in the gradation of this bidirectionality, we can for example include interactive fictions or simulations, which require the player to undertake an active role in communication. In this typology, games are not means of communication, but spaces for communication.

To analyze how serious games in health are communicating, in view of the theoretical framework outlined above, we will make a comparative analysis of the strategy of communication in a sample of serious games identified in the health area, with the communication on traditional information / communication campaigns.

3. Methodology

3.1. Base model

In the definition of a communication campaign, Rogers and Storey [10] propose a conceptual model to represent the variability of these tools in terms of their objectives and effects. The model has three axes, which should be seen as continuous: (1) level of objectives (represents the vast diversity of goals and results that are intended to be achieved in a communication campaign, in a continuum with 3 key points: inform, persuade, mobilize), (2) locus of change (represents the level where the effects of a campaign are to be produced: individual, group / organizational / or societal), and (3) locus of benefit (represents who benefits from the success of the campaign communication: the sender, the receiver, or both). Although the graphic representation of the model does not seem to indicate a particular correlation between the different axes, it is a helpful tool as it generates a very clear picture of the diversity of possible communication campaigns, with regard to its objectives and effects.

For our analysis, we will adapt this authors' model (Fig.1), integrating a fourth continuous axis that reflects the sense of communication in the game (which in a campaign is essentially unidirectional). In this way we will also be able to observe how games involve the player in the communication process, assigning him an active role in health

communication through games. This axis of analysis materializes the previous theoretical reflection, representing the player's participation in the game, and consists of 4 key points: (1) co-creation (games where participation occurs through the co-creation of the game), (2) ownership (games where participation takes place in the interactivity between the player and the game), (3) social (games with a social aspect, which promote participation through the creation of communities), and (4) inbuilt (games that enable human-machine communication). Based on the previous reflection, we also made a slight adaptation to the level of the objectives, making the objective of awareness more visible, since this may be an objective in itself in the light of participative approaches to communication. Based on these four axes, we will make the proposed comparative analysis.

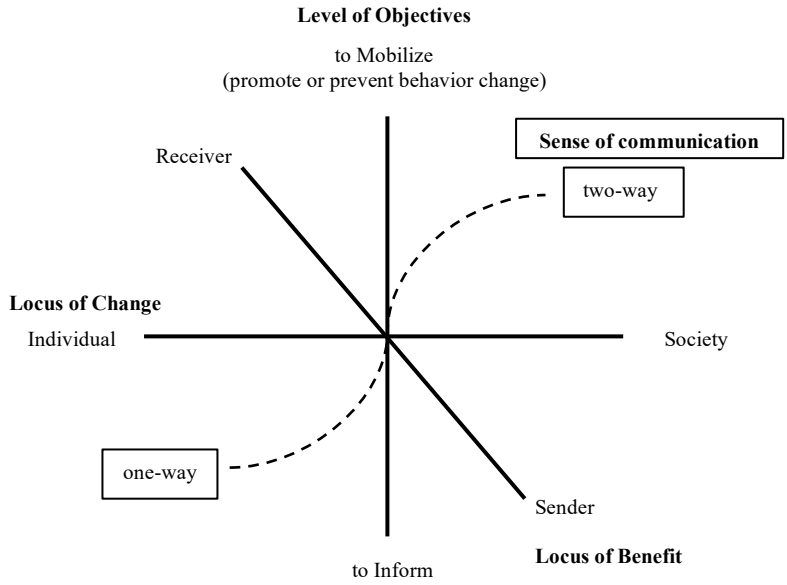

Fig. 1. Base model used for the analysis, adapted from the model of Rogers & Storey (1987).

3.2. Method

We can find countless and diverse serious (purposeful) games [28] in health, from online mini trivia games, to games in the virtual world [3], what leads us to the need of reducing the complexity of the analysis in number and diversity of representations (as mentioned earlier, we use a wide definition of *serious games* [62]). We want to ensure, however, that our sample of games is significant for the analysis, i.e., that it contains a diversity of games with different approaches to strategic health communication. Thus, in the paper we will take the database of *Games for Change* (G4C) [63] (May 7, 2020), in the "health" track. The aim of G4C is to empower game creators and social innovators to bring about changes in the real world through games and immersive technologies. Among other actions, G4C works as a project incubator and games curator for the

public. Its vision is "(…) help leverage entertaining games with non-entertainment goals and transform them into a compelling and convincing communication tool" [64]. It is this framework that led us to choose the G4C database. By including the category "health" in the list of games, as well as in the contest categories, G4C expresses that it wants to create impact and produce changes in health area. On the other hand, it sees serious games as entertainment games, with a potential for fun on the level of commercial ones, which has been difficult to achieve [65]; and as "convincing communication tools", which suggests that G4C brings together a diversity of approaches, that explore games in their potential of communication, including new technologies, such as immersive. A quick glance at G4C database points us in this direction. Despite the focus of the *Health Games Database* [66] in the health domain – a repositorium that we could also consider for this analysis -, the *Health Games Research* project [67] ended in 2013, and the database is currently obsolete (with most games out of access).

4. Results

Table 1 presents the games found under the health category in the Games for Change platform classified according to the four axes mentioned (see 3.1), in a total of 35 games. Of these 35, 3 were withdrawn, as they address topics only indirectly related to health. It should be noted that among them we find games developed within research programs or projects (e.g. *Re-Mission* or *Mindlight*), commercial games (e.g. *Plague Inc*., or *Skip a Bit: Heart Rate Game*) and independently produced games (e.g. *Mainichi* or *That Dragon Cancer*). This diversity in the origins of game design seems to make its objectives and effects less demanding compared to those of traditional communication campaigns. Although all G4C games have a serious purpose, they seem to accept the premise that games can be built to shake consciences or criticize social issues, without producing immediate measurable results in players or in society. This means that the variability of communication options in this universe of games is greater than, for example, a sample of games focused on the behavioral change of players.

4.1. Level of Objectives

At this level, we can conclude that G4C mainly seek to mobilize and to raise awareness. Several games have an implicit action, related to the health theme in question, without actually transmitting information or trying to convince the player (as commonly done in traditional communication campaigns). The action and interactivity inherent to gaming (examples are *Mindlight* or *Zombies, Run!*) present an enormous advantage, by mobilizing not by persuasion, but by the engaging power of the games. Other games, however, follow a more common approach to campaigns (such as *One Leaves*), putting facts and arguments in a game-play context, and within an experiential approach.

A significant part of the G4C analyzed are just an alert of conscience or games of empathy [68] in regards to a given theme - examples are *Auti-Sim*, *Beyond Eyes* or *Mainichi* (independently produced), but also *Hellblade: Senua's Sacrifice* (a commercial game). This is an objective far distant from those in traditional

Table 1. Analysis of games from Health track in G4C – objectives and effects.

G4C (Health)	Level of Objectives				Locus of Change				Locus of Benefit			Forms of Participation (Dir. Comm.)						
															Inbuilt Comm.			
	I	P	M	A	I	G	O	S	S	R	3rd	CC	Ow	Sc	Int	Bio	Dat	Art
A Closed World				x		x			x	x								x
Alpha Beat Cancer	x				x					x			x					
At-Risk	x						x		x	x	x				x			
Auti-Sim				x				x	x	x								x
Beyond Eyes				x				x	x	x								x
Bounden	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-
Caduceus				x			x			x	x		x					
Cancer Game	x				x				x	x			x					
Code Fred: Survival Mode	x				x					x			x					
Depression Quest				x				x		x								x
Family of Heroes	x					x			x	x					x			
Healing Spaces			x		x				x	x								x
Hellblade: Senua's Sacrifice				x				x	x	x								x
Mainichi				x	x			x		x								x
MindLight			x		x					x						x		
Narcoguerra	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-
Nevermind			x		x				x	x						x		
One Leaves		x			x					x			x					
Papo & Yo				x				x	x	x								x
Plague Inc.	x				x				x	x			x					
Please Knock on My Door				x	x			x	x	x								x
Re-Mission			x		x					x			x					
Re-Mission 2			x		x					x			x					
Sea Hero Quest	-	-	-	-			x				x						x	
Skip a Beat Heart Rate Game			x		x					x						x		
SmokeSCREEN		x			x					x					x			
Start the Talk	x				x				x	x					x			
Superbetter			x		x					x				x				
SuperSight	x				x					x			x					
That Dragon, Cancer				x				x	x	x								x
The Unstoppables				x				x		x			x					
Unmanned		x						x		x			x					
Uplifted			x		x					x					x			
Valiant Hearts: The Great War	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-
Zombies, Run!			x		x				x	x			x					

I/P/M/A (Information/ Persuasion/ Motivation/ Awareness); I/G/O/S (Individual/ Group/ Organization/ Society); S/R/3rd (Sender/ Receiver/ 3rd parties); CC/Ow/Sc (Co-Creation/ Ownership/ Social); Int/Bio/Dat/Art (Interactive/ Biofeedback/ Data/ Art).

communication campaigns, as we mentioned earlier, because it is less assertive. Even public will campaigns aim to produce effects, in this generating consensus and mobilization for policy changes, which is not the case in empathy games.

4.2. Locus of Change

In our sample of games, the locus of change is mostly individual. But there are also games with a more comprehensive target, that seek the group, organizational or social transformation. *A Closed World*, a game about the challenges that the LGBTQ youth face daily, was designed to bring about transformation within a community, due to the perception of institutional homophobia in game culture [69]. *Family of Heroes* also seeks to produce transformations in a group, in this case supporting families of returning veterans, and the veterans themselves, in adjusting to post-deployment life [70]. Some games, like *Caduceus* or *At-Risk*, have an organizational focus. *Caduceus* is a key content element of *Generation Cures [71]*, a pediatric medical research awareness and fundraising movement, that exposes young players (ages 8 to 12) to the concepts of altruism and compassion [72]. As kids conquer each of the game levels, portions of their sponsors 'pledges are unlocked and donated to Children's Hospital Boston [72]. In *At-Risk*, an interactive mental health game, the aim is to prevent suicide in the context of University, training students and Faculty staff to recognize signs of psychological distress such as depression, anxiety, and substance abuse [73]. Finally, empathy games or those that seek to criticize social issues (e.g. *Unmanned*), have a broader social scope.

4.3. Locus of Benefit

The locus of benefit of G4C games is not always that of the player (receiver). It can also be for the game developers themselves, when the game is commercial (e.g. *At-Risk*, *Zombies, Run!* or *Papo & Yo*), when it is an academic project (e.g. *Healing Spaces* or *A Closed World*), or when it is a form of personal expression (e.g. *That Dragon, Cancer* or *Papo & Yo*). The game can also benefit third parties when the locus of change is organizational, but also, for example in *Sea Hero Quest* - a game for understanding how people navigate 3D environments, to help develop early diagnostic tests for dementia and Alzheimer-, which involves external stakeholders, namely Alzheimer's Research UK , researchers from the University College London and the University of East Anglia, and the Deutsche Telekom [74].

4.4. Direction of communication

Built on the basis of our initial theoretical reflection, we have identified several games that mainly follow the game-*based learning* theories. These can be informative/ educational, persuasive [75, 76], or promotional of a social critical reflection (e.g. *Unmanned*). *Digital game-based leaning* (defined as "any marriage of educational content and computer games" [28]), is in fact the basic approach applied to most serious games in the field of health [53, 77]. In addition to simple learning games [78, 79], game-

based learning also structures complex games, which bring together a set of other theories according to its objectives, such as *Plague, Inc*. (which follows the principle of problem-based learning [80], in addition to incorporating epidemiological models for the spread of infectious agents). The message is transmitted throughout the game, triggering the retention of information by the player, and the training of this cognitive learning. Despite the apparent linearity in this communication strategy, as we saw earlier, digital games are distinguished by its interactivity. The game engages and motivates the player in the communication, but it is his agency and interactivity with (in) the game that reveals the message, and that allows the player to take its ownership [35], bringing some freedom in the sense of communication. In this way, the player participates in the communication. This approach falls under the concept of *ownership* in the fourth axis of the analysis and examples are games like *Alpha Beat Cancer*, *Code Fred: Survival Mode*, *Unmmaned* or *Re-Mission (1 and 2)*.

Taking into account point 3 (social) of the same axis, we find a game (*Caduceus*) with a collaborative strategy [81] but that is played individually, thus undermining a possible social aspect of the game. *Superbetter* is the only game that integrates a social component [82], by which players can become allies, check in with each other and be supportive, promoting Social Resilience.

In addition to these games, at G4C there are still others like *At-Risk*, *Family of Heroes*, *Start the Talk* or *SmokeSCREEN*, that integrate the player's feedback (options or choices) in the game's narrative. These are mostly interactive fictions or interactive game-based simulations, since they clearly endorse an *interactive communication* with the player. They are part what we previously called *inbuilt communication* (games that enable human-machine communication). Although they do not promote a real communication between the machine and the player, they are close to a bidirectional sense model since they demand an active role in communication from the player.

A very particular case, in this context, are the games that promote the feedback of biometric parameters within the game [83]. This is the case of *Mindlight* (whose gameplay involves the player's neurofeedback), *Skip the Beat Heart Rate Game* (whose interactivity focuses on the player's heartbeat), or *Nevermind* (which also unfolds based on biometric feedback). For the player to advance in these games, he must be able to model his emotional state, rather than his behavior. The game assumes a real two-way communication between the player and the machine, with the purpose of learning, training or entertainment. There is no real exchange or sharing of ideas (communication is not merely cognitive based [84]), but rather a discovery of the player, and a change in his own perceptions, about himself, through *biofeedback communication*. Now, although this fact is not identifiable with an interpersonal approach to communication, it certainly breaks the linearity that is typical of the mass media communication.

In another sense, we have *Sea Hero Quest, a* game designed to collect data about the spatial orientation of the players, that we identified under the concept of *data communication*. In this game, communication acquires meaning especially for its developers, although the game's storyline [85] certainly has an especially emotional meaning for the players, volunteers in the research.

In conclusion, despite not finding any game built by AI (as one would expect), we can distinguish at least three models of G4C that go beyond interactivity and social

aspects in the game, to constitute true spaces of communication between the designer / machine and the player, and thus of player´s participation, namely interactive games (fictions or simulations), games based on the feedback of biometric parameters, and games that collect data from players through gameplay.

To these we add a fourth type of games, which are very close to works of *Art*. Many games of this type (most of them are empathy games) are forms of self-expression of the game's developers, and address health issues that are dear to them, close to their experiences (such as *That Dragon, Cancer [86]* or *Papo & Yo*); or issues that they consider important (as in *Beyond Eyes* or *Hellblade: Senua's Sacrifice* [87]. As such, games assume the role of expressive objects [88]. The game as an expressive work of art is not only an action, but also its result; not only artistic, but aesthetic, "framed by enjoyed reactive perception" [88]. This means that the game developer's personal act is organically related to its objective outcome. The way the themes (material) are portrayed, makes them alive in the sphere of individual experiences [88]; the game as a work of art has the quality of living in the realms of imagination and experience. Unlike scientific forms of communication (or statements), these games express meanings. They do not lead the player to an experience, but rather constitute one. They have the unique quality "of clarifying and concentrating meanings contained in scattered and weakened ways in the material of other experiences" [88]. This means that they evoke meanings and emotions [89, 90] that are more part of a ritual vision of communication than of a transmissive, unidirectional one. If we compare playing a game and reading a newspaper, according to the vision of James Carey that "would have less to do with sending or receiving information, and more (…) with a situation in which nothing new is learned but in which a particular view of the world is portrayed and confirmed. " [91]. For some, this ritual vision of communication may raise doubts about its effectiveness [92] but the expectation is that it will revive memories, emotions and associations that open the door to a change in mental framing.

We can then conclude, in this line of thought, that a digital game can constitute a space of shared communication between the designer and the player, in a *ritual* and experiential vision of communication. In the conception, the game designer assumes a participatory role, according to the participatory approach to health communication - expressing his point of view, his emotions, doubts and anxieties, often involving third parties, as in *Hellblade: Senua's Sacrifice*, where designers " sought the help of psychosis patients, who described what it was like to live with things like voices in their heads." [90], or in *Beyond Eyes* [93]. Such a game constitutes an experience, but it is also purposefully designed to do so. And here interactivity plays an essential role, since the experience as defined by Dewey [88]" [is] the result of the interaction between an individual and the environment at a given time."; or as Calvillo-Gámez, Cairns & Cox [35] point out regarding video games, between the user and the game. Once again, the potential of serious games as a means of communication in health is confirmed, with expressive advantages over traditional formats of information/ communication campaigns, from the point of view of entertainment, engagement, and a more flexible communication that allows individuals to play an active and intervening role in communication.

5. Conclusion

From our results, we can conclude that there is a clear difference between strategy of communication in G4C in the health track, and that of traditional information/ communication campaigns. G4C encompass diverse approaches, revealing the enormous flexibility of serious games as tools for the design of innovative forms of communication. Because G4C do not (or do not always have) the requirement to produce measurable effects on players (part of them are produced voluntarily and independently [68]) they often have an awareness-raising or a social critique approach. In these cases, they fundamentally aim to challenge society, seeking social changes rather than individual ones. Interrogating, more than pointing a path. Involving the players, rather than deciding for them. Games can also constitute a form of self and artistic expression, helping for instance the designer to cope with painful situations [86]. Only a few games follow a persuasive strategy, which is the most common in traditional campaigns. G4C with an individual behavior change strategy primarily seek to inform or educate players, or alternatively to motivate and mobilize for action.

In addition to this clear distinction between digital games and traditionally mediated campaigns, we identified four types of games on the paper´s G4C list that embody what we called as inbuilt communication: (1) interactive games (fictions or simulations), (2) games based on the feedback of biometric parameters, (3) games that collect data from players through gameplay, and (4) games as expressive objects or works of art. These games, more than media for (a transmissive) communication, constitute spaces of communication. Although they do not allow a true bidirectional communication, they instill the player to participate in the communication process. Video games designed using artificial intelligence systems (e.g. Prom Week [61]) are rare, especially due to their high production costs. But in research, the possibilities of Human-Machine communication are increasingly being explored, suggesting a change in paradigm concerning the role of the machine in communication, between mediator vs. communicator [94].

The greatest contribution of this paper is the understanding of the potential of games, as engaging and flexible tools for health communication strategies. Based on the paper´s theoretical framework, and inspired by the work of Mitgutsch, Schirra & Verrilli [95], we have developed a hybrid game in the area of nutrition and healthy eating, that seeks the participation of players under the concept of *inbuilt communication*, with all the advantages of face-to-face communication [91, 96-98].

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Magical Board Theatre: interactive stories that can be played on multiple boards – two educational prototypes

Demetrius Lacet[1,2][0000-0003-0988-2815], Filipe Penicheiro[2][0000-0002-8784-3355] and Leonel Morgado[1,2][0000-0001-5517-644X]

[1] Universidade Aberta, Coimbra, Portugal
[2] INESC TEC, Porto, Portugal
Leonel.Morgado@uab.pt

Abstract. Interactive storytelling uses in education are limited by the time required for its production and the ephemeral nature of interaction systems, leading inter-active stories to have a short usefulness life. We have developed the concept of platform-independent interactive stories, called virtual choreographies, enabling interactive stories to be replayed on novel technological platforms as they emerge, tackling the second half of this problem. The first part was also approached via a graphical storyboarding approach. Both aspects have been prototyped in a demonstration, called Magical Board Theatre ("Teatro de Tabuleiro Mágico", original Portuguese name). We present this prototype, including its storyboarding tool, summarize the virtual choreographies ap-proach, and demonstrate how the prototype operationalizes them with story and platform examples.

Keywords: board games, digital storytelling, xAPI, interactive storytelling, virtual choreographies, multiplatform

1 Introduction

People's immersion with stories, be they in novels, movies, or other media, surpasses the industry's ability to produce them. This is apparent from phenomena such as fan movies, which are now part of con-temporary popular culture, and an intertextual tendency across media, permeating social culture [1], originating the concept of Transmedia Storytelling [2]. When stories are made interactive, they become yet a further medium, one that emerges from the intertwining of the agency boundaries embedded in the story by its creators and the agency exercised by the actual people engaging with it. As Neves et al. put it for videogames, one genre of interactive storytelling, "the game as a system and the player of the game carry out speech acts whenever play happens – the player plays in the terms of the system and the system is designed to enact those terms and to implicitly transmit what those terms are to the player" [3].

In education, these dimensions of immersion – absorption in the narrative, and absorption with challenges in interaction [4] – are a rich and powerful technique for engaging with core ideas, self-reflection, and other impactful dynamics of learning

[5]. The production of interactive multimedia content, in a creative and passionate context, is a mindtool, as Jonassen put it: “to engage learners in thinking deeply about the contents they are studying” [6]. However, production processes can be time-consuming, to the point of their feasibility in educational contexts being put into question [7]. Further, interactive digital stories are often ephemeral media. The modes of interaction and the rules that effect it are inextricably bound to a technological platform. Once that platform is rendered obsolete, its stories become unplayable, lost to memory, unless enough public enthusiasm manages to develop simulators for those platforms, which further limits the adoption of interactive storytelling in education.

Here, we present an approach devised to tackle this two-pronged problem, by combining interactive multi-platform virtual choreographies [8] that preserve stories across platforms, and visual storyboarding in a strict context, to diminish the time requirements for creating stories. This approach was implemented in the Magical Board Theatre prototype and tested with sample stories.

2 The Magical Board Theatre concept

Magical Board Theatre (“Teatro de Tabuleiro Mágico”, original Portuguese name) is a prototype platform for tabletop storytelling. It implements our approach of combining 1) easy of story creation with visual tools and 2) keeping interactive stories independent from their replaying platforms. In this sense, the Magical Board Theatre accepts multiple theatre “boards” with their own theatre “pieces” and “theatricals”: animated characters, static elements, area highlights, etc. These boards are not just obsolescence-prone visuals and code: each must include a semantic description of its theatrical affordances. This means that each board is seen as a specific, independent platform, and its semantic description, the “platform recipe” is a key element in the approach as described in the following section. In this paper, we exemplify this operation with two stories and their replay in different platforms without user intervention.

3 The Virtual Choreographies technique

3.1 Concept

Multi-platform virtual choreographies are the technique we leveraged to preserve stories across platforms, by rendering it interactive and definable by end users. Its core concept is that behaviours within a scene, of actors, objects, scenario properties, etc. form a “virtual choreography”. This choreography is expressed in that scene’s own thematic semantic space or “platform-independent & domain-dependent” ontology: for instance, mechanics using screwdrivers are expressed as such, not as “avatars using objects” or some other platform-specific construct [9]. Platform affordances are similarly described agnostically, in a “platform-dependent & domain-independent” ontology. By mapping such ontologies to each other, automated transformations

translate a virtual choreography into that platform's specific concepts, enabling it to be replayed without reprogramming (ibid.).

Fig. 1. Virtual Choreographies method to enable stories to be platform-independent [8]

However, authoring of choreographies as instantiations of ontologies is a complex process. We used the recent xAPI specification [10] to update the original virtual choreographies technique [9]. In brief, following xAPI all stories are sequences of statements, with a standard structure: actor, verb, place, object, and context. Thus, ontologies only describe the semantic space of such statements ("story recipe"). And platform ontologies ("platform recipe") are also based on these structural elements. By matching a story recipe with a platform recipe, any choreography written using that story recipe can be re-played on that platform. Conversely, if a new platform provides its recipe and its matching with an existing story recipe, all stories writ-ten using that recipe can be replayed on that platform (**Fig. 1**).

3.2 Adding interactivity

The original approach [8] enabled interactivity, because since each story was itself an ontology, an inference engine could react to environment changes, produced by a user or some other agency. However, that approach did not consider explicit prompts for interaction, which is a common mechanics in interactive storytelling. For instance, in

the first interactive video story, Kinoautomat [11] a moderator would regularly ask the public to choose among options that would conduct the narrative. In paper form, the same concept became popular culture in the 1980s through interactive books in series such as “Choose Your Own Adventure” and “Fighting Fantasy”[12]. The concept remains active today, with significant media exposure given to the interactive movie Bandersnatch on Netflix [13].
We have implemented interactive storytelling into our approach by considering that specific actors can be responsible for providing options and choosing. For instance, a story recipe can have a “Narrator” actor to enable stories to present options out of the blue (without having to assign the provision of options to a proxy character). Similarly, story recipes can have an “User” actor, to enable stories to express the concept that the storytelling needs to wait for a user input. Since xAPI statement sequences do not hold world state, we re-act to these interactions by explicitly expressing storylines in the story, as contextual outcomes of those decisions, within the “Context” section of each xAPI statement.

4 Storyboard Editor and Recipe Matcher

The visual storyboarding tool aims to enabled non-expert users to create stories, i.e., virtual choreographies. Firstly, the story author must choose a specific story recipe or provide a new one. It is the semantic space of that story recipe that determines the possibilities made avail-able in the storyboarding tool: actors, verbs, places, contextual items, etc. The tool then operates by leveraging traditional interaction approaches in the field of interactive narratives, such as Twine [14]: story statements are presented as individual blocks, which can be connected to each other as a graph (**Fig. 2**). Interaction moments originate a storyline fork in the graph, which can be kept or eventually joined at some later story point.
The resulting graph is then serialized into a JSON file, following xAPI.

Fig. 2. Connecting two statements (left), and a story graph (right).

The same graph-based tool is also used to match story recipes with platform recipes. For instance, a disjoint set of blocks representing the actors in a "Star Wars" story recipe can be connected to another disjoint set of blocks in a board platform recipe. For instance, Actor "Darth Vader" (story recipe) can be mapped to Actor "Black Knight" (castle platform recipe) or to Actor "Batman" (comics platform recipe). As another example, a verb such as "Go to" in a story recipe can be associated with "Move" in a 3D board platform, but with "Change comic strip background" in a comic strip board platform, since that's how actors "go" somewhere in a comic strip.

5 Three replaying platforms

As a proof of concept, four platforms were created:

1. a comic strip platform;
2. a 3D fantasy castle;
3. a game room with a tabletop map of the Iberian Peninsula;
4. a game room with a tabletop diagram of the periodic table.

Each platform includes its own media resources, such as characters, visual environment, audio materials, etc. as exemplified in Fig. 3.

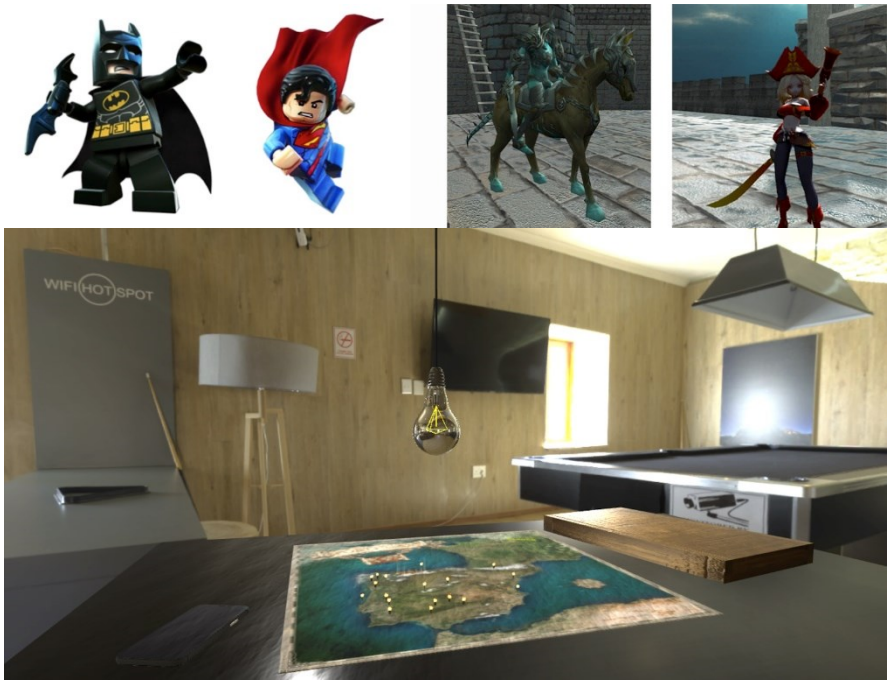

Fig. 3. Sample Magic Board Theatre media resources: superheroes in the comic strip platform, knight and woman pirate from the castle platform; and visual environment of the game room platform, with the tabletop map of the Iberian Peninsula.

6 Sample Story Recipes and Stories

6.1 Story Recipe 1: Star Wars universe

Our first trial with story recipes was inspired by a sequence from the movie Star Wars: The Empire Strikes Back [15]: the famous "I am your father" occasion, when the Darth Vader characters reveals this to the main protagonist, Luke Skywalker. This scene has been reimagined numerous times in alternative media, narratives, and popular culture (**Fig. 4**), which led us to consider how a recipe could be built to enable creators with the freedom to create those various reinterpretations.

Fig. 4. Sample "I am your father" reinterpretations found in online media

The entire scene was idealized for a single location, known as Cloud City, as indicated in its storyboard (**Fig. 5**). We have two characters, dialogue, and some movement, hence the recipe shown in **Fig. 6**.

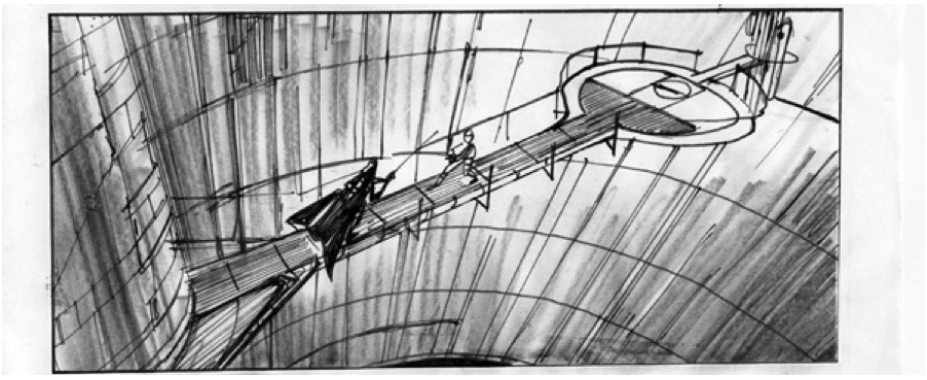

Fig. 5. Duel on Cloud City storyboard,
http://theswca.com/index.php?action=disp_item&item_id=48231

The recipe has one actor for each character: "Luke Skywalker" and "Darth Vader". One place, the location "Cloud City". And three verbs, for being at; going somewhere; and speaking. There is a context element: the content of speech. We might have considered other context elements, such as stance for motion, emotional cues, etc.

```
{"starwars": //recipe name
      {"Actors":["luke_skywalker","darth_vader"],
       "Places":["cloud_city_core"],
       "Verbs":["IsAt","GoTo","Speak"],
       "Context":[{"Content":"text"}]}
      }
```

Fig. 6. Story recipe for "I am your father" reinterpretations

With this recipe, countless virtual choreographies (stories) can be created. A sample choreography is shown in **Table 1**, just with speech.

Table 1. xAPI statements reinterpreting the "I am your father" scene.

Statement 1		Statement 2		Statement 3	
Actor	Darth Vader	Actor	Luke Skywalker	Actor	Darth Vader
Verb	Speak	Verb	Speak	Verb	Speak
Place	Cloud City	Place	Cloud City	Place	Cloud City
Context: Content	Obi-Wan never told you what happened to your father?	Context: Content	He told me enough. He told me you killed him!	Context: Content	No, I am your father!

The actual rendering of this story will depend on the platform. The recipe simply enables stories to be told acknowledging these actors, verbs, place, and contextual elements. For instance, a platform might use the indication of "Actor: Darth Vader" to decide on a visual representation, an audio timbre, a specific text font size, or some more complex combination of elements. The platform will have its own elements, and it's the matching process (described later) that will map a story recipe's elements to a platform recipe's elements. The choreography is always expressed in the terms of the story recipe, and the platform-adapted choreography, generated automatically, is the one executed by the platform, on its own terms, and with its own media resources and rules.

6.2 Story Recipe 2: Portuguese "Reconquest"

For our second trial, we considered the educational context of a piece of Portuguese History, the so-called "Reconquest" period of political and military instability between opposing social formations. It refers to a long period of time between the VIII and XIII centuries, of major activity from "Christian" kingdoms against Muslims who were established in the Iberian Peninsula at the beginning of this period. It's not an unequivocal name, since it contains multiple perspectives on economics, politics, society, and culture, far more complex than a simplistic notion of conflict among homogenous blocks or unidirectional advance of one side "recovering" land [15]. The

apologetic and somewhat triumphalist character of chronicles about this period tend to diminish the multiple ebb and flow inherent to the occupation of a territory that would become the kingdom of Portugal, as well as ignoring the multiple alliances between Christians and Muslims in different fighting contexts.
The process of resettling lands and power exchanges after various conquests of cities within current-day Portuguese territory can be exploited visually to support a better grasp of these dynamics. A particularly visible dynamic is the successive conquest and loss of territory and cities in the XI and XII centuries over the "Mondego line", up until Portugal's independence was asserted in 1143.

Thus, we considered how a recipe could be built to enable creators with the freedom to create various stories of the Portuguese Reconquest dynamics, which we presented in shortened form in **Fig. 7**.

```
{
 "Reconquest":{
 "Actors":["knight", "traveler", "crusaders"],
   "Places":["Lisbon", "Oporto", "Coimbra", "Cadis"],
   "Verbs":["is", "go", "dialog", "choose", "hide",
"play"],
   "Context": [{"content":"text"}, {"url":"text"},
{"storyline":"text"}]}
}
```

Fig. 7. Shortened version of the Reconquest story recipe.

Like with the "I am your father" recipe, choreographies (stories) can be created with this recipe. Instead of using a table, we present a story following this recipe serialized in JSON format in **Fig. 9**, and an example rendering in **Fig. 8**.

Fig. 8. Story of **Fig. 9** being played in platform 3: game room with a tabletop map of the Iberian Peninsula.

```
{
   "actor":"knight",
   "verb":"dialog",
   "place":"Cadis",
   "context":{
      "content":"In the year 711 the Moors invaded the
Iberian Peninsula, from Gibraltar.",
      "url":"https://site/in-711-invaded.wav",
      "storyline":"intro"
   }
},
{
   "actor":"traveler",
   "verb":"dialog",
   "place":"cadis",
   "context":{
      "content":"And what happened?",
      "url":"https://site/and-what-happened.wav",
      "storyline":"intro"
   }
},
{
   "actor":"knight",
   "verb":"dialog",
   "place":"cadis",
   "context":{
      "content":"The BATTLE OF GUADALETE – The Moors won
and it was the end of the Visigoth Empire.",
      "url":"https://site/guadalete-battle.wav",
      "storyline":"intro"
   }
```

Fig. 9. Virtual choreography (story) based on the Portuguese Reconquest story recipe

7 Matching recipes and playing the stories across platforms

7.1 Matching story recipes with platform recipes

In order for a virtual choreography (story) to be playable on a platform, a match must be created between the story recipe followed by that choreography and the platform recipe providing the semantic space of the platform affordances. This can be a plain 1-on-1 match, as shown on the following tables, but using the xAPI context element, we can also provide specific rules for each match. For instance, assume that a platform only has a single character, but enables it to be rendered alongside text: the context element for the matching of “Luke Skywalker” with “Default Character” could

establish the text “Luke Skywalker” as context, and the platform could then use that text as overhead text to distinguish that character from other visually identical ones. A similar approach could enable the matching with non-visual platforms, such as text adventures or others.

Table 2. Matching the “I am your father” story recipe with platform recipes 1 and 2

Story recipe: “I am your father”		Platform recipe 1: comic strip platform		Platform recipe 2: 3D fantasy castle platform	
Actor	Darth Vader	Actor	Batman	Actor	Knight
	Luke Skywalker		Superman		Pirate
Verb	IsAt	Verb	Show	Verb	Be
	GoTo		ChangeBack		Move
	Speak		Balloon		Talk
place	Cloud City	place	Factory	Place	Castle

The comic strip platform will play the stories replacing Darth Vader with Batman and Luke Skywalker with Superman. The verb for being at some place is simply used to tag a character as being visible in upcoming scenes and the verb for going somewhere is converted into background changes. Speaking becomes showing a speech balloon. This enables stories following this receipe, like the story in **Table 1**, to be rendered in this comic strip platform, as shown in **Fig. 10**.

Fig. 10. The story from **Table 1** rendered in platform 1, via recipe matching.

Similarly, the matching of the story recipe with the platform recipe for platform 2, the 3D fantasy castle, enables the outcome shown in **Fig. 11**.

Fig. 11. The story from **Table 1** rendered in platform 2, via recipe matching.

We have similarly matched the story recipe with the tabletop platforms (3 and 4), resulting on successful renderings. **Fig. 12** shows how "I am your father" is now the revelation done but the Crusader character to the Traveler character in this platform.

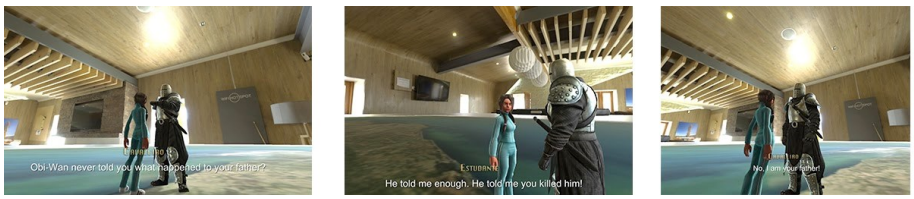

Fig. 12. The story from **Table 1** rendered in platform 3, via recipe matching.

8 Conclusions

We have presented a system that enables stories to be played across multiple platforms, without requiring recoding. The approach of turning xAPI on its head from documenting events to specifying events was successful and can be a powerful technique against obsolescence of interactive storytelling. Even though this occurs with semantic approaches, the visual storyboarding tool enables the creation of semantic stories to be done by non-expert users, thus potentially empowering teacher and students alike to participate in engaging the educational community in this new medium.

Further work exploring the feasibility of the interactivity approach described in the paper is still required, as is exploring the feasibility of further platform types. For instance, considering automated interactive video generation of stories, with adequate intelligence for deciding on camera movements based on story elements, would enable yet another pathway for future enjoyment of interactive storytelling.

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Playfully probing practice-automation dialectics in designing new ML-tools

Jorge Ribeiro[1][0000-0001-8188-0721] and Licínio Roque[2][0000-0002-1911-2788]

[1] Universidade de Coimbra, Coimbra, Portugal jamr@dei.uc.pt
[2] Universidade de Coimbra, Coimbra, Portugal lir@dei.uc.pt

Abstract. Aircraft maintenance is a complex domain, where organizational practices and system changes are rare and require new practices to slowly evolve. In the context of creating a planning tool for Condition-Based Maintenance in Aircraft Maintenance Planning (AMP), authors were faced with the challenge of designing for a not-yet present culture. In this context we introduce domain language and procedures and discuss the use of play probes as a cultural probing technique, to enable a dialectics between experiential development of new planning practices while facilitating cooperative design of a new tool.

Keywords: Play Probes; Cultural Probes; Paper Prototype; Playful; Maintenance; CBM; Machine Learning

1 Introduction

The aircraft maintenance domain poses new challenges for the design of decision support systems where human and machine learning confluence can open new opportunities. However, such a critical operational context is highly regulated and resists experimentation. A recent project was started with the intent to research and develop new AI-based tools for exploiting the large amounts of sensor data, to enable closer estimates of maintenance needs, through enhanced diagnostics and prognostics.

Such a scenario raises new and relevant challenges for design approaches that can cope with evolving current practices in the field in conjunction with designing for human appropriation and control over new ML tools. Under such context we can't perform ethnography of as yet not-existent practices, neither can we apply conventional requirements eliciting approaches. Instead, a participatory approach is needed to empower practitioners to develop new ways or working and designing ML-enhanced decision support tools. Such a scenario demands a generative approach informed by current practices and also new ML possibilities as they become available through research. Interdependence between new tool development and new practices in a strongly regulated context, inhibits experimentation, creating a cultural deadlock.

In here we will report on the challenges faced in this context and preliminary results while attempting to frame the design context. Namely we will speculate on the use of simulation games as a "play probes" approach, which can foster development of new practices as part of the evolving sociotechnical infrastructure in this domain. We also present a first experiment in workshop format for the use of play probes.

2 The Aircraft Maintenance Planning domain

Maintenance is a crucial factor in the aviation Industry. The main objective of maintenance is to increase the uninterrupted usefulness of the aircraft by avoiding component failures. Due to the complexity of aircraft and the large number of processes and procedures in planning and scheduling maintenance, a task-oriented methodology (MSG-3) [1] has been created to determine when and which tasks should be scheduled before each potential failure [2]. This has dramatically reduced the amount of maintenance done, but at the same time introduced unpredictability of when failures may occur. Currently, air regulations require that a predefined set of routine maintenance tasks be performed periodically, regardless of the state of the components or systems. This maintenance is usually grouped into sets of tasks called A or C check [3]. The most common, A-checks, performed ~ 4 times a year.

Maintenance planners usually plan checks more than 6 months in advance, taking into account that a large percentage of tasks have a regulated due date. However, many tasks in A-checks cannot be estimated far in advance. For this reason, planners leave a margin in the workplan to allocate new tasks that may arise due to variable wear or useful life. When it is not possible to allocate or postpone these tasks, specific maintenance stops must be done for corrective maintenance, which can induce delays or even costly flight cancellations. Because the planning of pre-established tasks is done independently of the state of components and systems, fallowing the rigidity of air regulations and procedures, renders maintenance quite inflexible and costly.

3 Addressing the Design of a new ML-enabled CBM Tool

The increase in the amount of data generated by modern aircraft sensors is enabling the application of predictive scheduling techniques in maintenance tasks. The data is processed using Machine Learning techniques and the result of these algorithms makes it possible to estimate the current life cycle state of the different components and systems in the aircraft.

To deal with the unpredictability of when failures may occur, research projects study new paradigms such as Condition Based Maintenance (CBM) [4] to use components and systems failure forecasts. Using these estimates to schedule maintenance at the most opportune moment, instead of using a fixed interval approach, can increase aircraft availability and reduce maintenance costs.

In the context of creating a planning tool for Condition-Based Maintenance in AMP, designers are faced with designing for a not-yet present cultural practice. It

is not possible to survey requirements from how activities are currently performed, since a new planning solution will include predictive indicators the planners themselves do not yet know how to explore. So, how can we design a new interaction approach for maintenance planning, and at the same time realize how the actors-network [5] can evolve to accommodate the CBM approach without risking current operation?

4 The idea of Play Probes

Cultural Probes created by Gaver et. al, is "An approach of user-centred design for understanding human phenomena and exploring design opportunities" [7]. Through the use of artefacts, the cultural probes allow participants collecting and documenting valuable activity data; introduce the participant's perspective in the process; allow participants to explore new ways beyond the expected. Adapting the concept of cultural probes could enable exploration of the CBM planning problem, while developing the participant perspective and appropriation of new tools [8].

Since Huizinga [9] the role of play in cultural development has been recognized. The concept of play probes has been addressed before in [10][11][12][13][14] in the context of studying novel interaction design proposals. The proposed Play Probes technique uses similar principles of Cultural Probes while exploiting games as a research tool to enable learning and data collection as already proposed by [15][16][17][18][19], but none of them uses the Play Probes approach in a computer simulation game.

Computer simulation has been used since computer development for modelling and studying systems [6]. Simulations have been used to formalize scientific problems and also adopted by academia in game form as a way to formalize and study economic and behavioral phenomena. Simulation enables the study of alternative scenarios without compromising the current operation. Turning simulations into games can enable exploration of behavior alternatives in future settings.

Play probes can be a research tool to address the planner dialectics between developing new practices for the CBM planning approach and the design of new tools. The challenge here is to adhere to well-defined aviation processes with its complex actor-network and at the same time researching a new interactive tool design. Play probes may be adequate to get in-depth information about user actions, attitudes and ideas with limited influence from the researcher. Enabling Aircraft Maintenance (AM) planners to engage with planning problems in the CBM tool enhanced context, turns participants into the main actors in eliciting requirements for the CBM process.

Planners currently perform maintenance planning in two stages: 1) Packaging tasks in a check; 2) Schedule checks according to the operation plan. These elements need adaptations in a new CBM-tool. To prepare the development of the play probes as a simulation game, we prepared basic elements to support paper prototyping sessions with basic visual elements. These elements include maintenance

and operation representations of plans currently in use at an airline operator. Failure prediction times for each task and check becomes a new element. Including interface elements for Remaining Useful Life estimates of aircraft components and systems creates opportunities for open conversations on how to adapt to CBM planning. Paper-based play probes enabled planners to roleplay with these indicators and gain sensibility for how they could exploit them in decision making.

In the following sections we present the first experiment for testing the play probes. We intend to validate both the feasibility of using it as a means of speculative discussion about a future decision tool and a possible way to collect information in a future executable version.

5 Preparing a play probe experiment

Participatory Design exchanges on paper have already begun to inform interaction design of simulation-based gameplay. Computational games loaded with realist operational scenarios will enable players to develop new planning practices, by considering questions such as: when and which estimates will be useful? what users would expect from plan generators and checkers? how players understand and interpret ML suggested plans and alternatives? how to exercise control over the plan-generating options and cooperate with the human domain competence? Overall, the intention is to understand how such a system could become the basis for organizational collaborations between operation and engineering divisions.

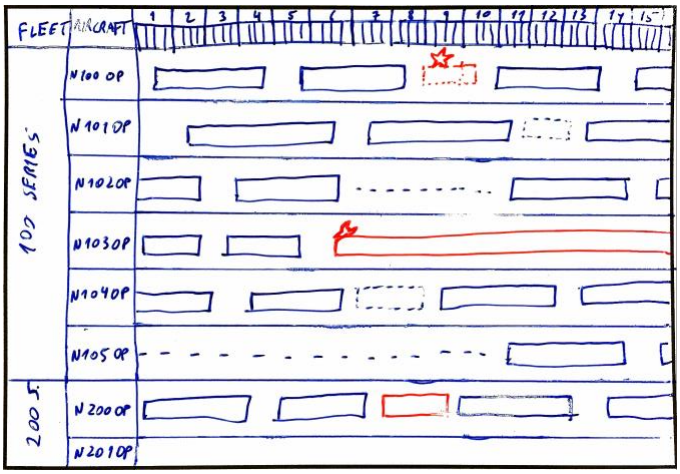

Figure 1 - Fleet scheduling maintenance checks

We opted to use a Participatory Design Workshop approach where participants roleplay trying to schedule a maintenance plan. The workshop methodology is comprised of 7 stages:

1. The first one was to prepare a solution path for solving the planning problem. The beginning of the resolution was linear, only possible in one direction, in

which the participants would be confronted with the simplest concepts of flight and maintenance movements.

2. In the second stage the basic maintenance elements from a maintenance schedule were identified (see Figure 1): **canvas**, the "background" of all artefacts, with all fleet information, time representations and time restrictions; **flight**, representing a flight of some aircraft; **block**, a predefined routine maintenance from MPD and **cluster**, a group of tasks that from the other kind of maintenance.
3. A paper prototype was tested on paper, and then was digitized to be ready for a virtual or online workshop.
4. This stage was an introduction for the participants, explaining what maintenance elements of the game are, and how a simple problem can be solved.
5. This phase was the experimental session, where the participants presented their ideas and manipulated the digital artefacts to solve the maintenance problem.
6. In the debriefing part we opened a space for a broader discussion, led by players.
7. In the final phase we inquired the participants, via email, with the intention to clarify or deepen the thoughts they had expressed during phases 5 and 6.

The drawing session involved four participants and the researcher. The profile of the participants is a mixed male and female, with research experience in computer science but no in-depth knowledge of the aircraft maintenance industry. The workshop experience will be described in the next chapter.

6 Running play probe experiment

In an initial part of the workshop, an introduction was made explaining the basic maintenance elements of the game and explaining how to solve a simple problem. In this part, lasting 10 minutes, the participants cleared some doubts about the game mechanics but did not interact with the artefacts.

The experimental session was presented to participants giving a non-trivial maintenance scheduling problem to be solved. The participant's voice and the collaborative canvas were recorded presenting their ideas and manipulating the digital artefacts to solve the maintenance problem. The facilitator was answering participants' questions about whether or not they could take some action, alerting them when they are not realizing something important, or trying to get them to explore the problem. This part lasted 26 minutes and 30 seconds.

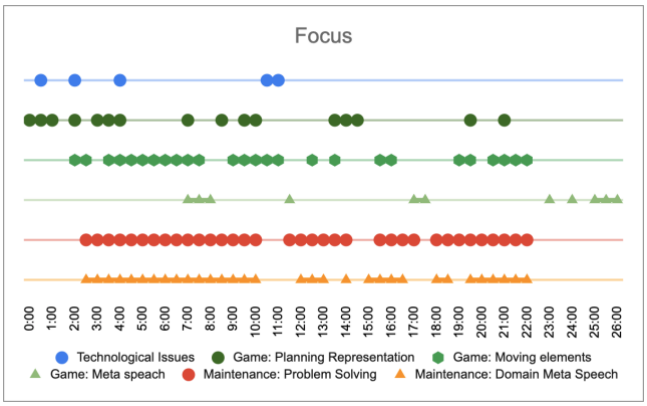

Figure 2 – Focus of conversation during experiment

The session developed in freely around solving the problem, with no constraints regarding management of concurrency among player explorations but favoring loud discussion in supporting each one's conduct. After participants solved the scheduling problem, a wider discussion space was opened, namely on the role Machine Learning could play in the planning process.

We listened to the recording, transcribed and coded into classes. Subsequently it was divided into 30-second segments and each one was classified into one or more classes. The two major areas are focus and reflection. Focus represents when artefacts of the game; reflection is when participants express some reflected thoughts.

The focus (see Figure *2*) can be immediate aspects: 1) on the technological tools used for the workshop; 2) on the planning game exercise that is divided on the interpretation of how planning is represented, 3) on the manipulation of the artefacts, and 4) on the conversation related to the Game as an instrument; on the maintenance that is divided 5) on solving the scheduling problem and 6) the aspects related to the maintenance domain.

The first two minutes were given to the participants to read the maintenance plan and to clear up some doubts before moving on to the problem. When we look at the focus of the conversation, we can see that at the beginning the participants talk about the representation of the planning artefacts and have some technical issues, which disappear from the middle of the experiment.

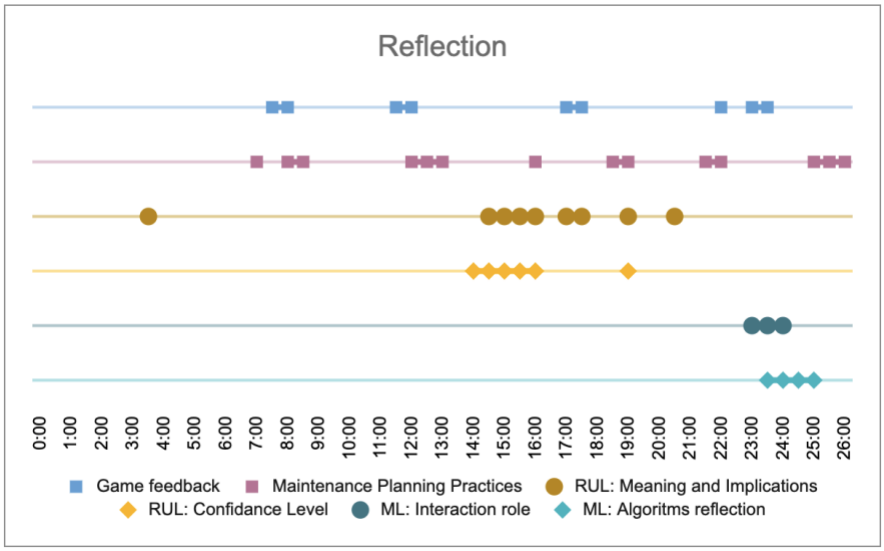

Figure 3 – Reflections of conversation during experiment

From 2 minutes on, right after the problem appears, the participants start to manipulate the artefacts of the game, something that happens almost simultaneously with the attempt to solve the problem. It is possible to observe that the meta speech related to the purpose of maintenance almost always happens simultaneously with the attempt to solve the problem. On the other hand, the meta speech related to the game itself happens a little later and is done when usually the focus is not on manipulating the game artefacts. It can also be observed that at 11 minutes, all the focus of the participants is no longer on solving the problem or on the meta speech but talking about the technical problem that appeared.

The reflection (see Figure *3*) is divided into four topics of conversation that resulted from a reflected thought: ideas for the improvement of the instrument (game); in the way the maintenance of the aircraft is being or can be done; in the degree of confidence, and the meaning / implications of the RUL indicator can have in planning; and finally how Machine Learning can interact with the planner or in relation to the operation of ML algorithms.

For the reflection conversation happens only after the 7 minutes of gameplay with one exception and the reflections happened less often than the focus event. The reflection about the game feedback and the reflection of the maintenance practices (blue and pink squares) do not happen at the same time but are usually subsequent with each other.

Reflections on the meaning of RUL as well as the confidence level take place mostly from minute 14 and simultaneously (yellow diamonds and yellow circles in see Figure *3*). The reflection on Machine Learning happens only in a final stage of the game, from 23 minutes on, both the reflection of the algorithms and the role of ML in the interaction of the game.

7 Conclusion

This study demonstrated that the probes, even in an environment that replicates a paper prototype concept, can serve as a tool to channel the dialogue to useful aspects, a priori intended for investigation, without being placed in a confrontational perspective, but rather being suggested in conversation by the participants themselves, as part of the playful environment. Regarding the two probes proposed in this study, a healthy and fruitful dialogue was generated regarding possible directions for new cycles of this study.

In spite of the interaction limitations inherent to a paper prototype in a game design exercise, this study was able raise relevant questions about ML and RUL in AM planning and collect useful information to understand how to evolve for the next DSR cycle.

When participants put themselves in the role of planners, quite empathetic suggestions emerged for planers interaction with ML such as allowing to fix certain maintenances and calculate just the rest of the planning plan, as well as presenting more than one solution to planners, taking into account different metrics. This exercise allowed the participants to put themselves in a relaxed, yet reflexive, environment to play and learn collaboratively how to deal with a high-risk problem.

As future work and in order to achieve better results, we will analyse further interviews, to compare diverse exercises with aircraft maintenance specialists.

8 Acknowledgments

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Conducting a Usability Playtest of a Mathematics Educational Game with Deaf and Hearing Students

Lília Marcelino[1], Conceição Costa[1,] Andreas Melo[1] and Fernando M. Soares[1]

[1] CICANT - Lusófona University, Portugal
lilia.marcelino@ulosofona.pt, conceicao.costa@ulusofona.pt

Abstract. In this paper, a usability playtest to a pre-Alfa version of "Other-worldly Math" is presented with a focus on understanding, usability, and player experience based on the four-layer model from Player Research. The main goal of the present study is to improve learning and the game experience of a mathematics research-based educational video game with the application of a usability playtesting. The participants are deaf and hearing children (n = 9), four deaf students and five hearing students, aged between 10 and 14, five girls and four boys. Four instruments were applied via Zoom platform: a) a pre-test, to collect players' video games preference; b) a post-test to gather participants' self-report on difficulties they may found in-game; c) an observational grid for researchers; and d) an emotional scale to assess the intensity of emotions felt by the players in-game. The main results show that deaf and hearing children felt "very" satisfied and "a little" confused during gameplay. It was found that both groups found the same barriers: a) the objectives of challenge 2 were not understandable; b) a user interface icon meaning is ambiguous in challenge 3; and c) players expect more exploration in every challenge. A new level design and a new game layout were developed to fix the problems found in challenge 2. The usability problem related with challenge 3 demanded icon redesign. In what relates to the playability issue mentioned in c) the solution points towards a game design review to balance the learning objectives with playability.

Keywords: Research-based Educational Games, Deaf Students, Games User Research, Usability Playtest.

1 Introduction

The evaluation of user experience (UX) in video games is more complex and challenging when compared to the so-called productivity software. The ease of use and its well-known associated users' productivity and satisfaction is not enough. Players are not only performing activities to accomplish goals in their personal or professional lives, such as making a hotel reservation or using home banking services. The scope of analysis should be extended from tasks to a meaningful context of a subjects' interaction with the world, including the social context [1] and emotions involved [2, 3]. In this perspective, a video game is still a product, but a one that engages and immerses users in a meaningful experience [4, 5]. In good video games or Game-Based Learning

(GBL) approaches, players/students are engaged and immersed in an activity when they receive no apparent rewards except the activity itself. Therefore, educational content should be integrated intrinsically in the playability [6 - 8]. Moreover, all game creation process should be focused on the very pioneer and actual concept of Huizinga [9]: "In play, there is something *at play* which transcends the immediate needs of life and imparts meaning to the action." (p.1).

Game UX considers the whole experience players have with the game itself - from interacting with menus and controls to the emotion and motivation felt during and after gameplay [10]. Furthermore, Game UX interfaces with the three pillars of video game creation: Design, Art, and Programming [11]. Besides, to understand the whole players experience, usability cannot be ignored. It is necessary to take in account the human limits in attention, perception and memory; it also means anticipating design errors that can be made and being prepared to find solutions for them as well to know and work with the expectations and abilities of the audience [12]. Moreover, the game design process should be more even more attentive to human factors when the audience is deaf and hearing students struggling with mathematics.

The relevance of video games in the learning and cognitive enhancement process has been increasingly studied. Video games could be integrated into the educational process in several ways, such as through the use of commercial games or the creation of games with previously defined learning objectives [13,14]. This potential of action on cognition is crucial to the increase of multiple skills, resulting in improved performances in several areas of knowledge, including mathematics [14,15].

Keeping this perspective in mind and sustained by previous research, the research-based educational video game under development in project "GBL4deaf – Game-Based Learning for Deaf Students" aims to research the mathematics learning outcomes of participating students. The video game "Otherworldly Math" is as a tool to support mathematics' learning having deaf and hard of hearing students (DHH) as the primary audience. An iterative Games User Research (GUR) process integrated in the game pre-production and production is used in the project research design. In project "GBL4deaf – Game-Based Learning for Deaf Students", the focus of game design is an active learning and student-centred learning approach.

The involvement of deaf and hard of hearing (DHH) players/students as participants in UX evaluation bring complex issues and challenges. The researchers could not interact directly with students. An interpreter is needed taking the risk that something can be lost in the process of translation. Another problematic issue is the absence of sign language researchers. Observing a DHH participant could be more complicated than watching a hearing participant since body expression is also cultural. Other challenge is related to the materials and procedure: every instruction and written information presented in instruments should be translated to sign language, such as a questionnaire might not be understood easily by the participants, due to their deficit in the official language of the country.

In the current study, a usability playtest to a pre-Alfa version of "Otherworldly Math" is presented with a focus on *understanding*, *usability* and *player experience* based on

the three items of four-layer model from Player Research[1]. The main goal is to evaluate the player experience of the "Otherworldly Math" using a framework based on the four-model [16] with the application of a usability playtest to gather information about: a) participants' experience in video games; b) the ease of use and the fluidity of WASD/Arrow Keys movement response to different game actions; c) the adequacy of video game instructions based on PSL (Portuguese Sign Language) videos and corresponding subtitles in written official language of the country; d) players emotional feedback about the game experience; e) difficulties detected by participants and observers during the playability and f) problems identified by team observers during the playability.

2 Method

2.1 Participants

The sample was composed of four deaf students with a profound level of hearing loss and five hearing students. The participants, aged between 10 and 14 years old (five girls and four boys), attended fifth to seventh grade, except for a10 years old deaf boy who enrolled in the third grade. Deaf students' parents' level of education ranged between primary and post-graduate education while hearing students' parents' education level ranged between upper secondary and post-graduate education.

Table 1. Participants' characterisation by sample group

Variables	Group	
	Deaf (*n*=4)	**Hearing (*n*=9)**
Sex		
Masculine	2	2
Feminine	2	3
Age		
10	1	0
11-12	1	5
13-14	2	0
Mother's level of education		
Primary	1	2
Secondary	0	1

[1] The four-layer model from Player Research (a United Kingdom player experience consultant company) consists in answering the following questions: *Understanding* - Do players know what to do in the game world and what is available to them? *Usability* – Are players able to do what the game designers want them to do? *Player experience* – Is the game enjoyable? *Monetization* – Game developers need to generate profit.

Graduation	1	2
Post-graduation	2	
Father's level of education		
Primary	1	0
Secondary	1	1
Graduation	0	1
Post-graduation	2	3

Note. Level of hearing loss of deaf students is profound. Two participants are twins hearing brothers. Fathers' level of education = 1 missing value.

2.2 Materials

Video game "Otherworldly Math". The software used is an alpha version of a standalone game, produced with the Unity game engine. The "Otherworldly Math" game is a third-person camera game. The video game is a single-player with a cooperative multiplayer option and with a fixed orthographic perspective. The type of video game is Adventure/Puzzle/Arcade. The game art style contains a low-poly design, pure colours and sci-fi design defined in a consultation with a sample of students [17]. The game controller is a keyboard with a computer monitor as a display device and PC as an electronic device for Windows 10. The game is designed to be a mathematical educational game for formal and informal learning. The player must use mathematical abilities to solve four challenging puzzles to build a space base, but only three challenges are under study. Each challenge has three difficulty levels designed to provide the player with the use of progressively advanced mathematical knowledge and reward them with the resources necessary to build and upgrade their space base. Challenge 1 consists of an addition and subtraction puzzle in which the player must add or remove particles of an 'atom' to create a resource (see Fig 1.1 and. 1.2.).

Fig. 1.1. Challenge 1. Addition and Subtraction - Challenge Room

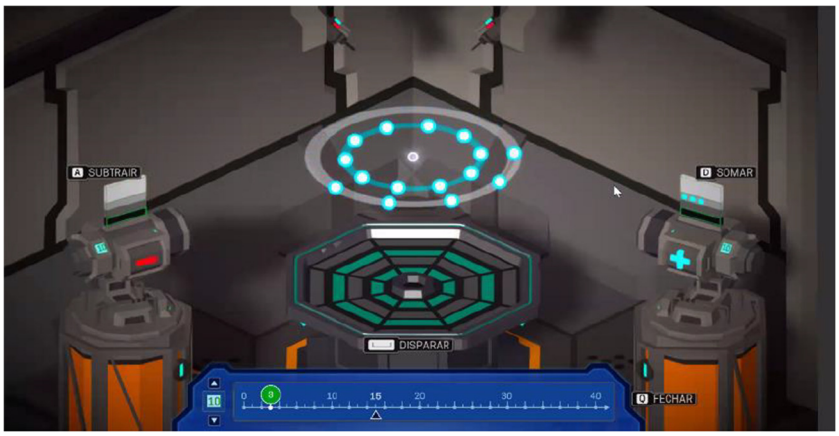

Fig. 1.2. Challenge 1: Addition and Subtraction - Challenge Game Screen.

Challenge 2 consists of a multiplication and division tasks in which the player must decide the number of cars needed to transport the produced gears. Still, they must determine the total amount to be made each round by using multiplication reasoning (see Fig. 2).

Fig. 2. Challenge 2: Multiplication and Division - Challenge Room.

In challenge 3, the player applied algorithmic thinking and notions of angles and rotations in a type of game known as turtle geometry to establish paths in a 5 x 5 grid by using step-by-step sets of instructions: turn to the right, turn to the left, step left, step right, step forward, step backwards (see Fig. 3).

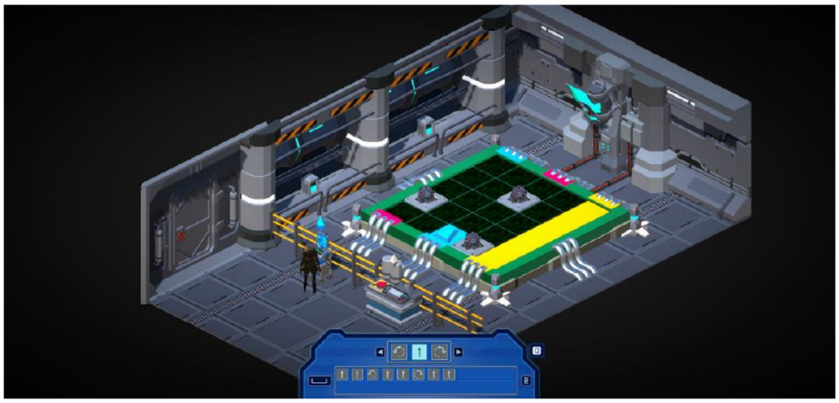

Fig. 3. Challenge 3: Algorithmic thinking, angles and rotations - Challenge Room.

Electronic Device. Laptop with Windows 10 software and a Mac OS X.

Usability Questionnaire. The survey, made in Google Forms, collects information about video games preference and difficulties reported by the participants. It consisted of nine questions: six applied before playing the video game, and three questions asked after the videogame. The pre-game questions are: (1) Do you play video games during your spare time?; (2) How many hours do you play games during the week? (none; 2-3; 5-7, 8-10; more than 10); (3) What games do you like most?; (4) Do you play games at school?; (5) Do you know what is a "bug"? (6) Do you ever find a "bug"? If "yes", in which game? The post-game questions are: (7) Did you feel any difficulty while playing the videogame? If yes, in which part?; (8) Do you think that it was easy to control the game character?; (9) Did you understand what the character was doing?

Observational Grid "Got it/Don't got it" (Swink, 2008) [18]**.** The observational grid is composed of 36 items for the four-game menus: introduction (items 0.1 - 0.9), challenge 1 (items 1.1 - 1.9), challenge 2 (items 2.1. - 2.9) and challenge 3 (items 3.1. - 3.9). The following nine items are incorporated into the introduction and in each challenge: (1) To start the game/challenge; (2) To navigate the level or reach the challenge level; (3) To observe the PSL (Portuguese Sign Language) tutorial; (4) To follow the instructions of the first stage gameplay tutorial; (5) To follow the instructions of the second stage gameplay tutorial; (6) To understand the objectives of the challenge; (7) To be able to play the first stage of the game with the tutorial help; (8) To be able to play the first stage of the game without the tutorial help; and (9) To successfully conclude the gameplay. Each item is rated using a dichotomous scale (got it/do not got it) to rank the performance of participants in each item. Also, a 5-item Likert scale is used to observers rated participants' experience (1= very low; 5 = very high).

Emotional Questionnaire. The questionnaire is a researcher-based scale based on the Positive and Negative Affect Schedule short-version (PANAS) [19] that evaluates the intensity of emotions felt by the players while playing the video game. Five positive

emotions were measured: satisfied, relaxed, involved, enthusiastic and excited; and five negative emotions: confused, bored, agitated, unsatisfied, and disappointed. Players asked to answer a 5-point Likert scale (1 = not at all; 5= extremely) to the following statement: "How did you feel while playing the video game?".

2.3 Procedure

In consequence of the evolving COVID-19 pandemic, the in-person work field with deaf and hearing students was cancelled and our sample stayed out of contact. In this context, was decided to recruit participants on the project site and social media networks as well to contact directly with deaf associations. Besides all the efforts, four deaf student participants and five hearing students were recruited. Informed consents were gathered from parents and children as well as questions about the participants (e.g. age, birth date, level of hearing loss, parents' educational level). Game download instructions were sent by email to the parents, and the usability playtest sessions took place on Zoom platform for a one-hour mean duration, approximately during three months. A PC and MAC version were available. Before the gameplay, a usability questionnaire was administered using Google Forms to gather information about the participant's video games preference. During the gameplay, the observers used the observational grid to take notes and rated the participants' performance. In the case of deaf students, a sign interpreter helped the test administrator to communicate with the deaf children. After playtest, the emotional scale and post-questionnaire were applied to participants.

3 Results

3.1 Players' video games preference

Table 2 shows that most participants played video games except a deaf girl with 13 years of age and a hearing girl with 12 years of age. Five participants reported five to seven hours per week of playing video games: two deaf and three hearing children with different years of age. Only one hearing girl stated that she plays more than seven hours per week. And none of them reported playing video games at school.

Table 2. Number of participants' playing videogames by sex, age and sample group.

Variables	**Play video games**		**Hours per week playing video games**			
	Yes	**No**	**0h**	**2-3h**	**5-7h**	**8-10h**
Sex						
Masculine	4		2		2	
Feminine	3	2		1	3	1
Total	7	2	2	1	5	1

Age						
10	1				1	
11-12	5	1		1	3	1
13-14	1	1	2		1	
Total	7	2	2	1	5	1
Group						
Deaf	3	1	1		2	
Hearing	4	1	1	1	3	1
Total	7	2	2	1	5	1

Table 3 presents the most referred games played by participants. The deaf children seem to be interested in games with a lower PEGI age rating, except Brawl Stars, which are video games that do not require a lot of quick reflexes to multiple stimuli on a screen. For instance, Wii Tennis is a video game that focuses on physical movement with a single focal point (the tennis ball). Minecraft has some environmental dangers, although the sandbox nature of the game means that the player can easily avoid them or build not to deal with them.

On the other hand, hearing children show preference in games like Tomb Raider, Rocket League and Fortnite. These video games are all fast-paced and require the player to be alert of multiple different sources of threats and opportunities which demands more time to master. In terms of platforms, both groups report the use of smartphones and consoles to play video games. Even though one hearing girl state playing more hours per week (8-10 hours), gender differences are not present. For instance, girls declared to play games as often as boys did. Differences between deaf and hearing in the number of hours playing video games was minimal, with deaf children playing slightly less hours per week.

Table 3. Video game type, age rating, and electronic device by sample group

	Type of video game	**PEGI age rating**	**Video game name**	**Electronic device**
Deaf	Adventure, Sandbox	7 +	Minecraft	P.C.
	Sports, Simulation	7+	Wii Tennis	Console
	Shooter, MOBA	10+	Brawl Stars	Smartphone
Hearing	Sports, Simulation	E	FIFA 19	Console
	Adventure, Shooter	PG-13+	Tomb Raider	Console/PC
	Adventure, Role Playing	9+	Harry Potter	Console/PC
	Shooter	12+	Fortnite	PC
	Shooter, MOBA	10+	Brawl Stars	Smartphone
	Racing, Sports	E	Rocket League	PC

Note. MOBA = Multiplayer Online Battle Arena; PEGI = Pan European Game Information; E = Everyone; PG = Parental Guidance.

3.2 Participants' self-report on difficulties found in-game

Eight participants answer to the post-questions, five hearing students and three deaf students. One deaf participant (deaf girl, 14 years old) give up playing the challenge 3 and did not answer to the post-questions.

When asked "Did you feel any difficulty while playing the videogame? If yes, in which part?", a common difficulty reported by children was the use of WASD keys to move the character in the isometric, third-person view. Two hearing students answered that "at the beginning no, but then yes" and one deaf and one hearing students answered "more or less".

Four participants in eight reported that they found it easy to navigate with the game character, two indicated that they found it 'somewhat easy' and the other two said that it was not easy at first. Still, it became more manageable after a while. No user stated that it was difficult to control the game character.

Concerning the answers to the post-question "Did you understand what the character was doing?", participants show knowledge about the game character actions. For instance, they stated that the game character was working, building something, a space base, ships, sprockets, etc. (n = 5), or collecting materials (n = 1) or answered "*Yes, I know.*".

3.3 Observation of participants during playtest

From the participants' observation, researchers identified five design problems in playability:

Lack of understanding of the objectives of the challenge 2. The goals of the challenge were not sufficiently clear to the player (Items 2.6 - 2.9). The "Got it" observers rating of the Item 2.6 *Understanding of the objectives of the challenge 2* was 56.25% with a mean "Experience" of 2.9 points. Some observers notes sustain the quantitative results: Observer 1. "Failed three times." - Deaf girl, 14 years old - Item 2.9; Observer 2. "Took a few tries, but she managed." - Hearing girl, 12 years old - Item 2.9.; Observer 3. "Only understood with (administrator's) help. She looks frustrated." - Item 2.7- Deaf girl, 13 years old; "Took a while to finish it. When he did, it was a sum. Player achieved the right result only because the 'sum' happened to be the same result as the desired multiplication (2+2 and 2x2)" - Item 2.7 - Hearing boy, 12 years old.

Video game instructions in Challenge 2. The tutorial language was not clear enough and could be confusing. The tutorial frequently skipped without being fully watched. Participants did not press the key Q to skip the tutorial instructions and often ended the tutorial without seeing the second and third instruction (see Fig. 4). The "Got it" observers rating of the Item 2.3. *To observe the PSL tutorial* was 68.75 % with a mean "Experience" of 3.1 points. Some observers notes mentioned the attempt to skipped without watching the tutorial: Observer 3. "Tried to skip with the mouse" - Item 2.3. - Hearing girl, 12 years old.

Fig. 4. Challenge 2 tutorial. First instruction: "You will transform metal in sprockets. The red light indicated the quantity of metal blocks that will get out of the machine."

The gameplay is too punitive in mistakes/failure. In challenge 3, the gameplay was long and challenging, and the player lost too much progress with each error, which was a source of frustration. Some observers notes mentioned frustration. Two players quit the game at this level (Items 3.5 - 3.8). Observer 1. "Failed twice and gave up." Item 3.8 - Deaf boy, 12 years old; Observer 3. "Always looking frustrated" - Item 3.5 - Deaf girl, 14 years old; Observer 4. "Gave up" - Item 3.8 - Hearing girl, 12 years old. When asked "What is the less positive part of the game?" the answer was "Challenge 3." - Deaf boy, 12 years old.

Ambiguity in the meaning of rotation icon. In challenge 3, many players made the same incorrect assumption over the function of a given UI (User Interface) object meaning the icon used for it was not clear enough. Frequently, observers noted the confusion and errors regarding rotation. In some cases, the player traces a plan which rotates 360 degrees without a step forward/right/left/backward (see Fig. 3). The "Got it" observers rating of the item 3.9. *The rate of participants' success in concluding the gameplay* was 68.75 % with a mean "Experience" of 3.6 points. Observers notes mentioned the UI icon ambiguity: Observer 1. "She did not realise that the arrows were for rotation only. She tried to execute the program as if the arrows would for rotation and move forward." - Item 3.7 - Hearing girl, 11 years old; Observer 3. "The rotation is confused. The player makes a 360 degrees rotation when it is not necessary". Item 3.7 - Hearing boy, 12 years old.

Lack of Undo game function in challenge 2 and 3. In both challenges 2 and 3, the absence of a 'undo' feature was reported by players. The "undo" function allows the player to correct their mistakes before 'testing' their solution. In challenge 3, players inquired the test administrator how to 'undo' or to erase in challenge 3 and how to return carts.

In observers notes one 11 hears old hearing girl asked: "How can I erase this?" - Item 3.6.

During the gameplay tests, the observers encountered three bugs (programming errors), but no exploits noted. On challenge 2 and challenge 3, there was a bug in which, after several attempts to solve the game tasks, the game would fail to reset appropriately for a new effort. This bug was no longer noted in all gameplay attempts, only a small number of them and all in which there were more than five failed attempts. On challenge 3, the observers noted that the tutorial failing to update even as a player performed the right actions correctly.

3.4 Players emotional feedback

Post-questioning players how they felt while playing the video game, most of the deaf and hearing children reported positive emotions like feeling "very" satisfied, enthusiastic and excited. On the contrary, they did "not at all" felt unsatisfied or disappointed. However, their emotional feedback in negative emotions indicated that they felt "a little" confused despite of being deaf or hearing children (*MD* = 2.3 and *MD*= 2.0, respectively), and "a little" bored (*MD* = 2.3) and "more or less" agitated" (*MD* = 3.0) in the case of the deaf children.

The children' feedback in opposite emotional states such as unsatisfied and satisfied are consistent. They felt "not at all" unsatisfied and "very" satisfied independently of the group (see Fig. 5).

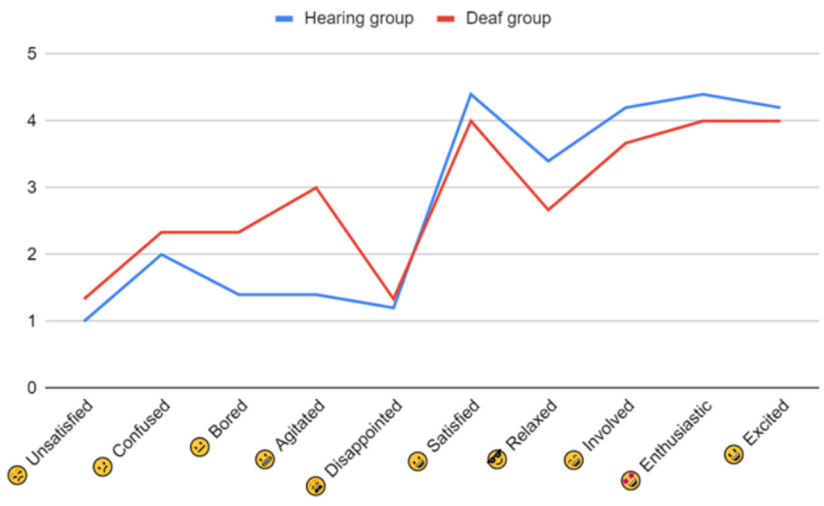

Fig. 5. Emotional feedback reported by hearing and deaf participants after playing the video game (mean values). Vertical axis: 1 = Not at all; 2= A little; 3= More or less; 4= Very; 5= Extremely.

4 Discussion

The present study aims to improve the game experience of a video game with the application of a usability playtest. Some solutions are proposed concerning the five design problems reported by observers and by participants (Table 4). For some problems, the answer was evident once the issues were detected (e.g. bugs), while others required a more in-depth reflection about the underlying issues.

Table 4. Design problems and proposed solutions

Design problems	Solutions
1. Confuse instructions on challenge 2 tutorial	To redesign the tutorial to give more clear and concise instructions. For instance, simplifying the language used to be more direct and include more images displaying the sequence of solving the challenge (see Fig. 4).
2. Lack of understanding on challenge 2 objectives	New layout to the Challenge 2 with more visual clarity and more contextual leads for the player. For example, to multiply the numbers of metals, rather than having it indicated by red lights, plus having the rail vehicles in a straight line, making them easier to count. Also, a system that gives feedback to the player about the number of rail vehicles incoming and the number of slots available for new rail vehicle (see Fig. 6).
3. Icon meaning ambiguity on challenge 3 	To create a new rotation icon to reduce the ambiguity. 
4. Challenge 3 too punitive of mistakes/failure.	To allow players progress to bet saved inside the same program  when multiple connections are necessary, requiring players only to repeat once the steps of a program.
5. Lack of "Undo" function on Challenges 2 and 3	To introduce the game function "Undo" to allow the player to change the game action.

Challenge 2 lack of clarity in the tutorial will be addressed by a review of the text used to convey the instructions as well as pairing them with a new image set. For instance, it was displaying a sequence of steps necessary to solve the challenge, rather than merely representing some of the elements that the player needed to pay attention. Additionally, the challenge received a new layout, and the new tutorial shall reflect that.

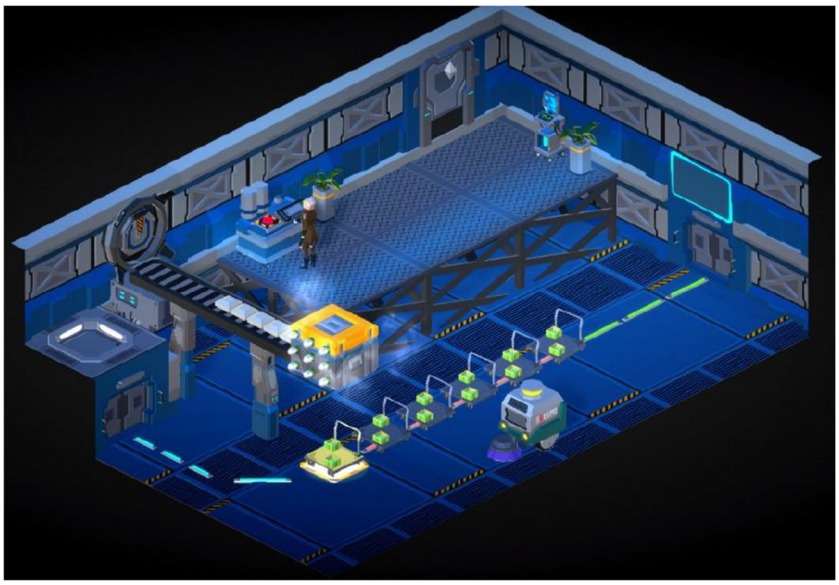

Fig. 6. New layout of challenge 2 (see previous layout, Fig. 4).

The lack of understanding of the goal and objectives of challenge 2 is not intuitively solved as some of the other design flaws perceived in the game. The problem of moving pieces presents a unique complexity and requires assessing many moving pieces at once to grasp its functionality fully. The solution implemented was to change the level layout of challenge 2, to erase the set of red lights that represented the quantity of metal that would leave the first machine, and instead explicitly show to the player the amount of metal. The rail with rail vehicles was changed to a straight line, making counting more perceptive, and some of the parameters to generate the challenge's 'questions' were changed to facilitate the player's first interactions with the task.

The ambiguity in the UI symbol for 'rotation' on challenge 3 can be solved by changing the icon to something that represents more clearly a quarter-circle rotation. For example, using a rounded form rather than a straight edge angle curve that could be confused with the straight edge lines of the grid, and thus read as 'step forward and turn' rather than just 'rotate in place', which is the correct meaning of the symbol.

The challenge 3 caused frustration in many players due to be too punitive of failure. In this challenge, the players were expected to successfully create three plans (with several steps each) using the 'programming' to command a robot to follow a path. In the original design, every time a player failed any of these plans, the challenge reset. The failure plan meant that a player who successfully finished program 1 and 2, upon failing program 3, would need to do the first and the second again before retrying the third one. Challenge 3 was hard to finish successfully in part due to the UI issues mentioned in the item above, and as such, the constantly redoing the program already completed was observed to be very frustrating to the players. The solution was to allow the

progress to be 'saved' between connections, only making the player repeat the last program they fail to conclude successfully.

During the gameplay, some players asked to the test administrator how to erase their solution because they realised they made a mistake. The game had no "undo" function. The players merely were advised of failure and then restart for the correct solution. Therefore, it was observed a frustrating behaviour on the players. The new version of the game has a UI function included in every challenge to allow players to 'undo' actions in each challenge.

Despite of any participant stated that it was difficult to control the character, a 13 years of age deaf girl - who declared any experience with video games - struggled during the first minutes of the playtest in controlling the avatar movement. She was not aware that she needed to keep the key pressed to move in a particular direction. Once this initial obstacle was overcome, she quickly displayed fast learning, and she was navigating as smoothly as some of the more experienced players playing 5 to 7 hours of games a week. This observation seems to confirm the idea that controlling the character would become more manageable if players were continuing to play.

The solutions proposed on challenge 2 may improve the emotional feedback given by deaf and hearing participants concerning feeling "a little confused".

The fact that some deaf students reported feeling a "little bored" and "more or less agitated" during the gameplay may be related with the problems detected in challenge 2 and 3. The tutorials were redesigned to remove ambiguity, moreover the possibility of saving the progress of step-by-step instructions, and the opportunity of using the "undo" function in all challenges may reduce boredom and stress. Another explanation may be concomitant to the online platform option for the usability playtesting due to Covid-19 restrictions. Besides having a sign interpreter in the usability playtesting sessions and the Zoom observers' windows keeping without video and sound during playability, online conditions may influence deaf students' emotions during playability. One possible explanation is associated with cognitive differences between deaf and hearing students. Behavioural and neurological investigations have shown that deaf people are more sensitive than hearing people to the redistribution of attention across visual space [20], and to the objects and movements in the peripheral visual field [21]. These facts have considered a response mechanism to monitor and to alert them about the changes of their environment since that do not have auditory signals. These cognitive aspects can lead to them being more alert, and visually distractible relative to hearing age-peers despite the observers' windows in Zoom platform was keeping without video and sound during playability to reduce noise.

The absence of interviewing deaf participants to understand better the "bored" and "agitated" aspects of the game is one of the limitations of the present study. In future iterations in usability playtesting, interviews with players will be part of the method.

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