THE G3P FRAMEWORK

guiding the design process of games for purpose

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ABSTRACT

Video games were created more than half a century ago and have rapidly become part of the common culture. Hundreds of video games are developed each year, differentiated by elements such as genre (e.g., puzzle or action), technology (e.g., virtual reality or handheld consoles) and audience (e.g., casual or hardcore gamers). Over the years, interest has grown in using video games for more *serious* purposes, intended to teach, train or inform. These games are designed exploiting a playful component to stimulate users to achieve specific goals. In general, video games have a complex design consisting of various interrelated elements and strongly influenced by the needs of players. The addition of a serious purpose increases this complexity, making the design of an effective product more challenging. This thesis focuses on the development of video games for purpose, proposing the G3P, a framework to drive the process of design. The G3P instantiates different game design theories in practice, adapting them according to a participatory approach in order to structure the design process. In this renewed perspective, different stakeholders are involved, contributing to the definition and articulation of the various elements of the game. In favour of this process the author presents the development of *Skies of Manawak*, a video game for neurocognitive training targeted at children with dyslexia. The design and implementation of this video game ran over two years and was divided into several stages. From the first conceptualisation to the release of the game, the stakeholders - domain experts and players - were involved. Each phase was aimed at the extension of the design and the revision of the overall work. The results collected from workshops and testing activities allowed assessing the effectiveness of Skies of Manawak in terms of player experience and cognitive training. In this regard, the analysis of the related work grounded the G3P framework; the various design activities held during the development of Skies of Manawak completed it. This manuscript represents a contribution to game design theories of video games for purpose, supporting the theoretical foundation of this research topic, still young but rapidly growing.

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STATEMENT OF CONTRIBUTION

This disclaimer is to state that the research reported in this thesis is primarily the work of the author and was undertaken as part of his doctoral research. Some passages, distributed over chapters 2, 3, 4, 5, 6 and 7 have been re-interpreted and rewritten starting from the following source:

> Menestrina, Z., De Angeli, A., Pasqualotto, A., Venuti, P., and Siesser, A. 2016. Participatory Design of a Video Game for Cognitive Training. *International journal of human-computer studies* (under review)

The development of Skies of Manawak involved various researchers and research fellows. For this reason, it is necessary to specify the actual contribution of the author in the project. The author fulfilled the following roles:

- Researcher: the author defined and managed the design process. He planned the stages involving domain experts and players, organizing the design activities and working on the collection and analysis of the data (sections 4.1, 4.2, 4.3, 4.5, 5.1 and 5.3). In regard to the final evaluation (section 5.4) he was mainly involved in the planning of the activities and the redesign of the video game (subsection 5.4.2); the cognitive scientist of the team managed the collection and analysis of data.
- Game designer: the author worked on the design of Skies of Manawak, in collaboration with the other members of the design team (sections 4.2, 4.4 and 4.6) and the stakeholders (sections 4.1, 4.3 and 4.5);
- Programmer: the author was the sole programmer and implemented Skies of Manawak in all its versions (sections 4.4, 4.6 and 5.2). The implementation included the writing of algorithms, the partial editing of audio and visual assets and the creation of animations;
- Project manager: the author coordinated the team managing in first place all the activities related to the design process of the video game.

In conclusion, any reference in the text to the "lead designer" or the "programmer" refers to the author.

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1. INTRODUCTION

Everyone played in her or his life. It is part of the growth of human beings, as well as animals, to play. The games can have many meanings, from the simulation of real-world situations to purely recreational activities (D'Urso, 2012). Whatever the reason, games and play are complex subjects, discussion of which involves various branches of science, such as philosophy, sociology and psychology. The early reflections can be seen in ancient Greece, with Aristotle distinguishing the game from work, equated to happiness and virtue (Abbagnano et al., 1974); yet, games can be found further back in human history, from the Mesopotamian civilizations. Over thousands of years, games, like society in general, have progressively changed, enriched by the contributions of many generations. Nowadays there is a broad variety of examples that show how games are part of our cultures, from sports to board games.

Around sixty years ago a new kind of game was invented: the video game. *OXO*, one of the first video games, was developed in 1952 as part of the PhD thesis in Human-Computer Interaction (HCI) of Alexander S. Douglas. Other similar experiments can be tracked down to 1947; however, only in 1958 was the first computer game conceived as an entertainment product, rather than for academic research or technology promotion, released: *Tennis for Two*.

Over the years video games became an established media. In the seventies Atari and other companies introduced the consoles, devices for home entertainment completely dedicated to play video games. Following this new opportunity in the entertainment market, the *golden age* of arcade video games of the late seventies led to a large distribution of these coin-operated machines and the related amusement arcades, where people could play various games, from *Pac-Man* to *Space Invaders*. Nowadays, video games have reached a market size equivalent, if not superior, to other forms of entertainment such as music and movies.

1.1. Video game research

Video games have not only influenced industry but also academic research. Studies on video games extend on a variety of perspectives. For example, a strain of research has focused on players and communities of play from sociological and psychological points of view: violence in video games affecting aggressive behaviours (Anderson, 2004; Smith et al., 2003); social dynamics in online games (Ducheneaut et al., 2006; Kolo and Baur, 2004); addiction to video games (Fisher, 1994; Wan and Chiou, 2006); gender inequality issues in video games and among players (Dill and Thill, 2007; Fox and Tang, 2014).

Another strain of research has been oriented to the understanding of the users and their interaction with the system, looking for example at the physical (Chen and Tsai, 2015; Rogers et al., 2015) or the mental interaction strategies (Iacovides et al., 2011, 2014). Other research has focused in particular on game design, developing diverse frameworks, design models and guidelines in order to formalize the structure of video games (Bjork and Holopainen, 2004; Schell, 2014; Sotamaa et al., 2005).

A particularly broad research topic that has grown in the last thirty years is the development of games intended to teach, train or inform. In this regard, several labels - *entertainment education*, *edutainment*, *game-based learning*, *digital game-based learning*, *serious games,* see Breuer and Bente (Breuer and Bente, 2010) for a review - have emerged. Even if each of these labels presents some differences, they share an interest in using games and video games for purposes beyond pure entertainment. Researchers have studied the potential of games to develop solutions for educational, training or informational purposes (Gee, 2010). These products have been used in various fields, such as military training (Lim and Jung, 2013), active aging (Brox and Hernández, 2011; Gerling et al., 2010) or education in general, where video games have been used for teaching diverse subjects, from history (Ardito et al., 2012; Costabile et al., 2008) to programming (Squire et al., 2004).

1.2. Video game design

Video games are complex systems structured on various elements, which can be summarized in what Schell defines as the elemental tetrad (Schell, 2014). Except for special cases (e.g., Tetris), video games have a *story* that provides the essential elements for understanding the objectives and keeping the player engaged. They also have an *aesthetic* that strongly influences the first impression of the user (Miniukovich and De Angeli, 2014) and facilitate a sustained level of immersion. While story and aesthetics are common to other entertainment products (such as movies, television series and theatre plays), the distinctive feature of video games is player interaction. This feature is defined by the *mechanics* and the *technology*. The mechanics set the basic rules of the game, shaping the space of the interaction between the player and the system. The technology concerns the apparatus with which the player interacts.

These elements - story, aesthetics, mechanics and technology (Figure 1) - are strongly interrelated and the design of a video game is a delicate process, where every choice on an element can affect the others. Considering games oriented to objectives other than entertainment the task is even more arduous. In fact, the

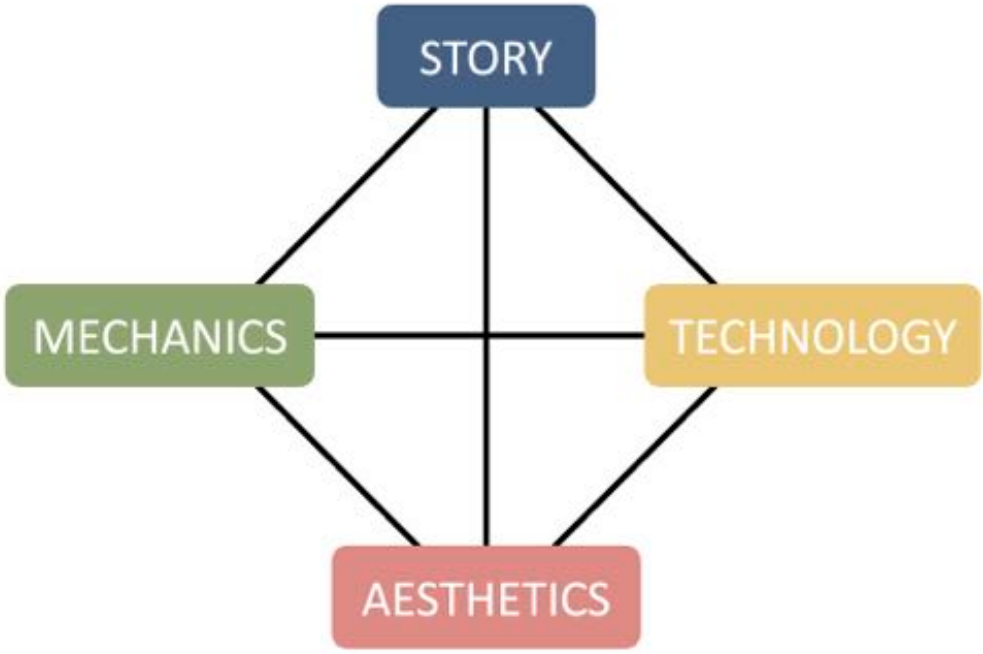

Figure 1. The elemental tetrad by Jesse Schell.

purpose adds another element to the system; the main design challenge lies in finding the right balance between the game and the goals that should be achieved while playing (Cuschieri et al., 2014). The game in this case is not merely an entertainment product, but also an instrument designed for a precise objective, such as math teaching, active aging or cognitive training; it should be effective in terms of the purpose but its design should still provide an immersive experience (Jennett et al., 2008; Nacke et al., 2010).

1.3. Research question

In recent years, research on games for purpose has grown considerably (Carter et al., 2014). In this regard, various studies highlighted the efficacy of these games in terms of their purpose and in some cases in terms of their player experience (Dondlinger, 2007; Egenfeldt-Nielsen, 2006; Wouters and van Oostendorp, 2013).

The interest in these playful solutions has also highlighted critical elements. One relevant concern of the academic community has been the lack of focus on the design process (Moser et al., 2014b; Vasalou and Khaled, 2013). Games for purpose are generally presented in terms of their efficacy, providing limited information on the design and development. Instead, in a research field where the final product plays a central role, the design process should be documented in detail. However virtuous examples - such as (Dodero et al., 2014; Gerling et al., 2012b; Moser, 2013) - are still limited in number compared to the overall research on the subject.

In relation to the design process, a few research studies explored the uses of participatory practices to game design, starting from the idea that the involvement of stakeholders would positively influence the overall design (Dodero et al., 2014; Gennari et al., 2017; Khaled et al., 2014; Khaled and Vasalou, 2014; Moser, 2013). In games for purpose the space for user involvement becomes larger, including other than the players, the domain experts (e.g. trainers, teachers or medical experts). The latter can provide an overview of the context and collaborate with the game designers in the definition of the goals. The former are the direct consumers of the product and thereby can provide information about

their preferences and desires. In general, it is unlikely that the game designers would have an a-priori full overview on the domain, due to the specific knowledge related to the purpose (e.g., no background in pedagogy) and the cultural and/or age differences with the target audience. Stakeholders can be a crucial element in the design process, bringing different perspectives and bridging the information gap that designers have on the design space.

While the lack of focus on the design process highlights a problem, the growing interest in participatory practices further emphasizes the need for formal models for the development of games for purpose. Although there are considerable studies on the design of these games (Annetta, 2010; de Freitas and Jarvis, 2006), the process is less explored and documented only in a relatively small number of cases. In this merit, the research question underlying this research is:

- *What are the key elements of the design process of games for a purpose?*

  The thesis proposes the G3P (section 6.3), a framework for the design process of video games for purpose, grounded on video game research and developed during the development of the case study of this research.

This question was deconstructed into specific sub-problems:

- *How is it possible to mediate between game and purpose?*

  The thesis proposes the elemental pentad (section 6.1), an extension to the elemental pentad by Schell (Schell, 2014) in order to reconcile the two.

- *How and to what extent can the stakeholders be involved in the process?*

  The thesis presents methods and tools for a design process oriented to the participation of stakeholders (documented and discussed in chapters 4 and 5).

This thesis focuses on the design process of video games for purpose proposing the *G3P*, a novel design framework based on well-established game design theories restructured following a participatory approach. The objective of this framework is the development of a balanced process, oriented to a high involvement of all stakeholders for an effective and engaging experience.

1.4. Case study

The framework emerged from a substantial action research on a case study focused on the development of a video game for cognitive training for children (8-13 years old) with dyslexia. The project was developed over almost two years from the collaboration between the Department of Information Engineering and Computer Science (DISI) and the Laboratory of Observation, Diagnosis and Training (ODFLab) of the Department of Psychology and Cognitive Science, both of the University of Trento, Italy. The work unfolded over several design iterations following an approach oriented to the participation of the stakeholders, including domain experts (cognitive scientists) and players. The former became integral part of the development team and were involved in all design stages, from conceptualization to implementation. The latter were involved in co-design sessions at various stages of the process. By reflecting on this practical experience, comparing and contrasting it with similar work (Khaled and Vasalou, 2014; Moser, 2013) and relating the discussion to well established game design frameworks (Hunicke et al., 2004; Schell, 2014), this thesis also provides methods and tools which could be used with the G3P framework to instantiate the design process of video games for purpose.

1.5. Outline

The thesis is structured in 7 chapters. Chapter 2 grounds the research on a review of the literature on game research, video game design, participatory design applied to games and technologies, and it reports a few research studies documenting the criticalities of the design process of games for purpose. Chapter 3 describes in details the case study, providing information on the background, the rationale of the project and the overall design of the video game for cognitive training. Chapters 4 and 5 present the design process. In particular, Chapter 4 introduces the stages that led from the ideation to the development of the alpha version of the video game. Chapter 5 focuses on evaluations and refinements of the game of the second part of the project. Both chapters provide a detailed description of methods and tools for the involvement of stakeholders in the design

process. Chapter 6 presents the G3P, a framework for the definition of the design process of video games for purpose, developed around a solid foundation of game design and oriented to a participation approach. The thesis closes with chapter 7, discussing the results and presenting further reflections on the limits and potential of video games for purpose.

2. RELATED WORK

The study of the related literature is presented in five sections: *game and play*, *games for purpose*, *video game design*, *participatory game design* and *video game development*. As the titles suggest, the general topics will be addressed first, followed by those at the heart of this research, also exploring similar research projects with a focus on the criticalities of the development. In general, the various sections are necessary for describing the knowledge base, but also to explain the philosophy of this work.

In this regard, section 2.1 explores game and play, two topics that, although deeply explored, still have a margin of interpretability. Clear definitions of what is game and what is play have been the reason for study of various scholars from different historical periods; as each of them has given the own interpretation, these are not always consistent, or have not looked to the issue from the same perspective. The reasons are many, of course, one of which it is the different scientific basis of these scholars. A particularly important factor is time. Game and play are influenced by social and cultural changes. A practical example is gambling, which has been seen differently according to the different historical phases (e.g., American poker, before relegated to riverboat casinos and now widely played in tournaments and online) and to different cultures (e.g., in Norway is largely illegal, while USA is widely played). Video games are no exception: given their recent introduction, how could Aristotle, or even Huizinga (with his *Homo Ludens*, firstly published in 1938) provide information that would reflect these new aspects? For these reasons, section 2.1 does not only focus on the analysis of research, but expresses the mind-set behind this work.

Similarly, section 2.3 presents research that debates game design with different approaches. These studies often propose solutions that address the game design from slightly different perspectives. Each of these projects has been an inspiration, but just a few were explicitly used in structuring this work, and a rationale of this choice is described.

2.1. Game and play

Game and play has been widely discussed in history by a large variety of scholars. Philosophers, psychologists and sociologists have analysed the ontological and epistemological meaning, leading to the fuzziness of these concepts. Smith (Smith, 2009) proposed three definitions of play focusing on *function*, *structure* and *self-appraisal*. The functional definition describes play as an activity that is performed for its own sake and does not have any external goal, such as the need to eat. The structural definition illustrates the types of behaviour that occur only in play, such as play signals. The self-appraisal definition emphasizes the actor's perspective, looking at self-reported evaluations of enjoyment, flexibility and pretence.

The functional definition has prevailed since ancient time in relation to the concept of game. Aristotle related the game to structured activities performed individually or in groups only in view of itself and not for other purposes or immediate needs (Abbagnano et al., 1974). Bernard De Koven considered the game as *"something that provides us with a common goal, the achievement of which has no bearing on anything that is outside of the game"* (De Koven, 2013). Similarly Huizinga (Huizinga, 2014) and Walther (Walther, 2003) reflected on the game as related to a voluntary activity somewhat closed in itself. It has its own pre-set rules and any action in the game is not aimed at a direct consequence in real life.

Other authors favoured a definition based on the player's appraisal of the psychological state, recognizing how the act of playing requires a specific attitude by a player, which Suits described as the lusory attitude: *"the voluntary attempt to overcome unnecessary obstacles"* (Suits, 2014). Similarly, De Koven (De Koven, 2013) elaborated on the concept of the spirit of the game, the individual's desire to play a game. Overall, there emerges a common understanding of playing a game as a voluntary act chosen by the individual to satisfy hedonic rather than functional needs.

From the functional perspective of defining play, the idea of games intended to teach, train or inform appears almost an oxymoron. Considering an application such as military training (Lim and Jung, 2013), the game has explicit objectives and is used to prepare the users to perform the same practices in the real world to be prepared with respect to the domain of interest. The game is oriented to a specific objective; the users play to achieve this objective in real life. With these premises, it is difficult to conceive this kind of play as a completely voluntary act, questioning the way in which these products can be labelled as games.

However, embracing a structural definition of play (Smith, 2009) the oxymoron can be partially resolved. Contrary to the functional approach, which looks at the purpose of the activity, the structural approach looks at the actual activity. The structural approach is at the basis of the pedagogy of play (Moyles, 2010; Smith, 2009). According to this emerging theory, play fosters development by allowing children to act out, grow and share their understanding of themselves, others and the world surrounding them. While playing, children put their knowledge of the real world to the test and increase their ability to communicate. Playing and learning must not be seen as oppositional activities (as implicitly suggested by the functional definition) but rather as possibly compatible outcomes of the same set of behaviours (as suggested by the structural and self-appraisal definition).

In the perspective of this thesis, video games for purpose can be considered games only in the moment in which the users can be considered players. This kind of software is transformed into game by the attitude of the user. Playing a game should not necessarily imply fun (Iacovides and Cox, 2015), but it should imply a lusory attitude (Suits, 2014), a playful interaction with the system. In these terms the purpose should be hidden: what Breuer and Bente (Breuer and Bente, 2010) define as a *stealth purpose*. Not a "frame of game" surrounding specific exercises, but an integration of these within the mechanics and the story of a game. The purpose should not emerge as a separate element of the design, aiming at a level of immersion (Jennett et al., 2008) that will make the experience enjoyable in a similar way to normal video games.

2.2. Games for purpose

The use of games for educational purpose has been studied since the 80s, with the early attempts of creating enjoyable learning games. In recent years the term more linked this research goal was *serious game*. Serious games have been largely used in various domains, such as military (Lim and Jung, 2013), healthcare (De Mauro, 2011; Felix Navarro, 2011; Göbel et al., 2010), education (Dekhane and Xu, 2012; Muratet et al., 2011; Nadolski et al., 2008) and emergency management (Chittaro and Ranon, 2009; El Mawas and Cahier, 2013). Breuer and Bente (Breuer and Bente, 2010) identified some other previous keywords, such as *entertainment education*, *edutainment*, *game-based learning* or *digital game-based learning*, that have been used years before the serious games. Even if these terms describe slightly different products (e.g., edutainment concerns target groups of children and pre-schooler and can be considered a sub-set of serious games; entertainment education refers to any attempt to make learning enjoyable), they reflect continuous research toward a compromise between play and learning.

Carter and colleagues (Carter et al., 2014) exhaustively analysed the last ten years of the game research published at the CHI conference (ACM Conference on Human Factors in Computing Systems). The authors highlighted the fact that games for purpose represent the biggest cluster (34%) of the overall publications in game research. Moreover, the authors identified a set of four research paradigms:

- *Operative:* games, play, or games research as an instrument used to exercise control over the world, such as favouring exercise or learning;
- *Epistemological:* game or play used to explore other topics or research areas (e.g., tangible interaction, interactive surface computing);
- *Ontological:* game research strictly related to the design and understanding of the ontology of games;
- *Practice:* similar to *Ontological*, but focused on the users and their interaction with the system.

The *operative* paradigm, defined as *"the first and most clearly distinguished",* concerns all the research in which games have been used for benefits, such as health and well-being or learning. Other researchers studied the efficacy of the operative studies; notably, a vast number of these works has focused on games for educational purpose (Boyle et al., 2016; Dondlinger, 2007; Sitzmann and Ely, 2010; Wouters and van Oostendorp, 2013), exploring in particular the efficacy of these products in terms of their instructional value.

These studies show an active and productive research, and a growing interest of the academic community on this topic. However, as pointed out by Marsh (Marsh, 2011), all the attention attracted by *serious games* have produced a misalignment in their meaning. The misalignment has not only concerned the formal definition of these games, but also how they are designed and applied. Marsh reconciled these divergences identifying a broad definition of the topic. In the author's view, these games are grouped in three categories:

- *Serious games as games for purpose*: video games with fun and challenging gameplay for purpose;
- *Serious games with reduced gaming characteristics*: game environments and simulations with fewer gaming characteristics for purpose;
- *Serious experiential and cultural purposes*: experiential and experimental environments with minimal to no gaming characteristics for purpose.

The main difference identified by the author in the application of serious games lies in their balance between purpose and engagement, where depending on the context the entertainment component could be subordinate to the purpose or vice versa. The categories defined by Marsh provide a clear overview of the use of serious games, from the ones more related to gaming activities to the ones more concerned to provide experience and emotion. Starting from Marsh's definition (Marsh, 2011) and the arguments of section 2.1, this work refers to *games for purpose*[1] as a term encompassing applications trying to reconcile a ludic and a functional component in the same product. In this sense, the descriptions,

[1] Not to be confused with *games with a purpose*, linked to human-based computation techniques.

discussions and reflections contained in this manuscript relate to this first category, conceiving the serious games as product designed in equal way for a playful and effective (in terms of the purpose) experience.

2.3. Video game design

A video game consists of many equally important components, joined together into a harmonious whole. Audio design and visual design are only a few of the manifold aspects that should be taken into account. Since video games can be considered as the result of a multi-dimensional design process, for an effective result all these elements should co-exist symbiotically.

While this might not be the case for other digital products, the user interaction is a key element in a video game. Rather than being mere observers, players are an essential part of it: the game is built around the experience that they will live; without them the game is virtually nothing. Quoting Newman *"the interface is a continuous feedback loop where the player must be seen as both implied by, and implicated in, the construction and composition of the experience."* (Newman, 2002). In other words, while products such as music or films are usually created considering the users as passive recipients, games are designed assuming an interaction by the players: if they do not play, they cannot generate the experience.

Models related to game design, particularly focused on the player and the game experience, proliferate in the literature. In *The 400 Project* (Falstein and Barwood, 2004), started in 2001 at the Game Developers Conference, Fallstein and Barwood aimed at summarising the elements for a successful game design in a set of informal rules. Reaching 112 rules in 2006, their main goal was to propose to game designers a set of rules of thumb to take in consideration during the design process. In a similar effort other researchers provided different sets of heuristics, studied and validated specifically for game design (Desurvire and Wiberg, 2009; Federoff, 2002; Laitinen, 2005; Pinelle et al., 2008). These works defined a user-oriented set of practical rules for the development of a correct game design

formula, focusing on dimensions such as game play, game mechanics, game story and game usability.

Björk and Holopainen (Bjork and Holopainen, 2004), Kreimeier (Kreimeier, 2002) and Schell (Schell, 2014) took these concepts to a more theoretical level. Björk, Holopainen and Kriemer, through the *game design patterns*, and Schell, through the use of *lenses*, proposed models meant to represent both a shared vocabulary and manuals on game design. Differently from the heuristics, this formalization provided more general rules, less tied to one type of game, or to a specific element, and easy to apply in the various phases of the development process.

Over the years, other game designers contributed to the analysis and definition of the structure of games and video games. Usually the main purpose of these works was the formalization of the design of games in order to support other game designers in modelling their projects. These works presented similar contributions, often differentiated by the perspectives of the authors over the topic (e.g., in some cases focusing more on the player experience, in others more on the core components of the game). In addition to the above-described works, Fullerton (Fullerton, 2014), Adams (Adams, 2014) and Salen and Zimmerman (Salen and Zimmerman, 2004) provided noteworthy contributions to game design. Their works spanned over various topics, including techniques and tools for the development of the design (Fullerton, 2014), the understanding of players (Adams, 2014), or the cultural meaning of games (Salen and Zimmerman, 2004).

In terms of formal elements of game design, the authors proposed quite different perspectives. Fullerton broke down games in eight elements: *players*, *objective*, *procedures*, *rules*, *resources*, *conflict*, *boundaries*, *outcome*. Players are the individuals (or groups) that have voluntarily accepted the rules and constraints of the game. The objective is the main purpose of the game; what players strive to achieve. Procedures define the actions that players are allowed to use in order to achieve the game objectives. Rules set the limit on player actions and generally define the behaviours of the game. Resources are the assets that the player can

exploit to accomplish the game objectives. The conflict is the emergent dynamic caused by the intent of the player to achieve the game objectives within its rules and boundaries. The boundaries constitute the magic circle, which separates the game from everything else. The outcome is the reward that the player receives for accomplishing the game objectives.

While Fullerton provided a quite specific set of formal elements, Adams (Adams, 2014) defined a few broader concepts. According to the author the key components of a game are the *core mechanics* and the *user interface*. The formers are the technical part of the game: the algorithms and mathematical models that set the general rules. The latter sets the interaction of the player, interpreting the inputs and providing the outputs according to the core mechanics. Some games have a third component, the *storytelling engine*, which represents the narrative of the game.

Salen and Zimmermann (Salen and Zimmerman, 2004) proposed an even broader decomposition of the elements of game. The authors presented the concept of *game design schemas* as *"ways of understanding games, lenses that we can apply to the analysis or creation of any game."* (Salen and Zimmerman, 2004). According to this framing, three primary schemas define games: *rules*, *play* and *culture*. Rules, similarly to the core mechanics of Adams, represent the mathematical model of the game. Play is the interaction of the player with the game and with other players. Culture defines the cultural context of the game.

Other studies provided less detailed analysis of the overall design of games, exploring in-depth specific perspectives. For example, Costikyan (Costikyan, 2013) focused on the importance of uncertainty - like the unpredictable outcome of a chess game - as an element for an engaging player experience. De Koven (De Koven, 2013) explored the various options of design and player interaction to achieve a well-played game.

In academia a few researchers proposed more specific solutions related to the development of games for purpose. De Freitas and Jarvis (de Freitas and Jarvis, 2006) formalized the design of games for educational purpose according to the

context of use, the *learner specification* (e.g., game preferences), the general *representation* of the game and the *pedagogical model* applied to its design. Annetta (Annetta, 2010) identified six intertwined elements for the design of a high quality educational game: *identity*, *immersion*, *interactivity*, *increasing complexity*, *informed teaching*, *instructional*. The identity refers to the relationship between the player and the digital avatar. The immersion relates to the flow (Csikszentmihalyi, 1996). The interactivity concerns the interaction by the player with virtual characters or other players. The increasing complexity is a basic feature of games to keep the player challenged. The informed teaching pertains the feedback and embedded assessments of educational games. Finally, the instructional can be considered the purpose of the game.

The approach to game design described in this thesis was mainly based on the works by Hunicke and colleagues (Hunicke et al., 2004), and Schell (Schell, 2014). Hunicke described the consumption of a game by the players through the Mechanics, Dynamics and Aesthetics (MDA) framework. The mechanics are the basic elements of the game that, through data and algorithms, define the rules (e.g., in Super Mario Bros. there is a timer showing the remaining time to complete the level). The dynamics are the emergent rules of the game, established at run-time (the timer generates time pressure). The aesthetics are the desired emotional responses in the player (the time pressure creates challenge). In regard to the latter, the authors proposed a taxonomy including, but not limited to, eight elements:

1. Sensation: game as sense-pleasure;
2. Fantasy: game as make-believe;
3. Narrative: game as drama;
4. Challenge: game as obstacle course;
5. Fellowship: game as social framework;
6. Discovery: game as uncharted territory;
7. Expression: game as self-discovery;
8. Submission: game as pastime.

The MDA framework is strongly oriented to the relationship between the designers, the game and the players, suggesting that the design of the game should consider the elements from different perspectives. The designers set the mechanics, which give rise to the dynamics, which in turn create the aesthetics. The players prioritize the aesthetic value of the game, which is caused by the observable dynamics, which in turn emerge from the mechanics. Thinking in the first place about the players and their experience inside the virtual world becomes a key element of game design. It is the responsibility of the game to keep the player engaged, because when players face a too challenging situation or a boring one, nothing prevents them from simply stopping playing.

Schell, in *The Art of Game Design* (Schell, 2014), defined a set of 100 elements, called *lenses*, used to identify the multitude of different facets of games. Between the various lenses, the author provided a decomposition of the game through the elemental tetrad. The elemental tetrad is divided in four dimensions. Mechanics are the basic rules (e.g., in Super Mario Bros. the player can move horizontally and jump, wins if the character reach the end of the level, loses if touched by an enemy); the technology is the physical medium (for the first release of Super Mario Bros., this was the Nintendo Entertainment System and a television); the story is the sequence of events (Princess Peach has been kidnapped and Mario has to go castle by castle to find and rescue her); the aesthetics represent the look and feel (pixel graphics and 8-bit sound effects). These four elements form the game and are strictly chained together. Their interdependence has a strong implication on the design, because any choice made on a specific element influence all the others. They are all the pieces that the game designers have in their hand, and even if some parts can be hidden from the player, they all deserve equal attention.

A few reasons influenced the choice of these MDA and the elemental tetrad. First of all, the two framework provide two complementary perspectives on game design. The former is more focused on the relation between designers, developing the game, and players, experiencing it. The latter identifies a complete decomposition of the design of games, less tied to the player experience and more

focused on supporting any reasoning of the designers about the real complex structure of their video games.

Another reason was the applicability of the two frameworks. While, for example, the frameworks proposed by Annetta (Annetta, 2010) and de Freitas and Jarvis (de Freitas and Jarvis, 2006) are exclusive to educational applications, the MDA and elemental tetrad refer to general video game design and are easier to apply to various contexts. Moreover, the above-mentioned frameworks tend to subordinate the entertainment to the educational purpose, clashing with the vision of the author of games for purpose (Marsh, 2011).

However, the application of the MDA and the elemental tetrad to the case study does not imply their greater potential over the other frameworks. In fact, the different models have various similarities; for example, the rules identified by Salen and Zimmermann (Salen and Zimmerman, 2004) resemble Adams' core mechanics (Adams, 2014), Schell's mechanics (Schell, 2014), and Fullerton's rules (Fullerton, 2014). As another example, Shell's elemental tetrad is less extended compared to the formal elements proposed by Fullerton, resembling more Adam's triad; on the other hand, the elemental tetrad is just one of the lenses, which in their entirety provide a complete overview on game design.

As described more in detail in chapter 6, these frameworks focus on the design artefact, while the G3P is mainly aimed at the definition of the design process. In this, the MDA and the elemental tetrad supported the definition of the participatory oriented process and the structure of the design of the game, and became part of the G3P. For this reason, other game design models and frameworks could be preferred by other researchers depending on parameters such as context and design space; still these could be integrated in the G3P without invalidating the framework.

2.4. Participatory game design

The users are not passive recipients of the entertainment while playing games; on the contrary, they are essential actors. Hunicke and colleagues assert that the interaction between players and games is different to other entertainment products (e.g., books, music, and plays) as the *"string of events that occur during gameplay and the outcome of those events are unknown at the time the product is finished."* (Hunicke et al., 2004). This centrality of players and the unpredictability of their interaction increase the importance of supporting a close dialogue with designers.

To guarantee a well-balanced design and widespread adoption, the industry, which in primis is interested in the value of video games, has established different ways to maintain a relationship with the players. For example, the playtesting phase is not only meant to identify bugs, but also to understand the player's perspective on the game and adjust the design accordingly (Johnson, 2012). According to Iivari and Iivari, this form of user involvement can be defined as consultative (Iivari and Iivari, 2011). This involvement is usually linked to the final stages of the development (Khaled, 2012); the exclusion of the players in the early stages of design is related to potential delays in the development phase, thus is not perceived as cost-effective. As a consequence, the ideation and preliminary phases of the process are directly entrusted to the designers (Hagen, 2011). However, there is a growing interest in the active participation of users in services such as *early access*, provided by Steam (the biggest online platform for games purchasing), which allows developers to release their games at an intermediate stage and then move forward in the development following a parallel dialogue with the users.

In this regard, participatory design is a topic widely explored in research and practice. From last century studies in Scandinavia, to the most recent conferences, an active involvement of stakeholders has always been considered of interest for the development of products made for and by the users. In video game development, a participatory approach is considered relevant (Fullerton, 2014),

but has not been widely used in practical applications (Khaled and Vasalou, 2014). However, considering games for purpose, the participation of the various stakeholders belonging to the context of application is almost a necessity: designers usually lack familiarity with the domain content (Khaled and Vasalou, 2014); similarly, they do not have a complete overview on the preferences of players, due to the generation gap, cultural gap, or even the dynamism of the video game market (e.g., video games of 2000 can radically differ from those of 2016). As Beck wrote, *"a player's perspective on game design issues is crucial to enhance the gaming experience."* (Beck et al., 2014).

The academic community has acknowledged the necessity of an active involvement of players in game design (Khaled et al., 2014; Lukosch et al., 2012) and in recent years various studies oriented the design process to the participation of stakeholders. In this regard, studies such as the ones by Moser and colleagues (Moser et al., 2014a), Khaled and Vasalou (Khaled, 2012; Khaled and Vasalou, 2014), Melia and Di Loreto (Melia and Di Loreto, 2014), Dodero and colleagues (Dodero et al., 2014) and Tan and colleagues (Tan et al., 2011) provided descriptions and reflections on methods and tools that could be applied in order to achieve this active participation.

The various studies showed interesting views on the participation of stakeholders, providing useful insights, but also demonstrating different ideas on participatory practices. For example, according to Khaled (Khaled, 2012) the players should play the role of *muses*: their preferences and desires should be used to enrich the game design, but they should not necessarily be involved in design roles due to their lack of literacy on the topic. Instead, Dodero and colleagues (Dodero et al., 2014) proposed to empower players in the role of game designers. The two approaches have both pros and cons: the former provides a more game-oriented design, privileging the quality of the design but potentially losing part of the users' contribution; the latter mainly focuses on the participation and the learning outcome, potentially neglecting the overall quality of the material outcome.

In this regard, in 2014 part of the community of reference had the opportunity to meet and discuss the subject, reflecting on the potential and limits of participatory practices applied to game design (Khaled et al., 2014). The various researchers recognized the importance of engaging the stakeholders in the design process, although their opinions highlighted different views on the enhancement of the participation. One of the main topics of this discussion was the involvement of children in the game design process.

The participation of children in the design of technologies is a research topic that started long before any specific application to video game design. Still, the discussions and reflections on the subject could also be considered valid for this technological subset. One of the main concerns of the researchers has generally been the level of participation of children. Read and colleagues (Read et al., 2002) identified a few elements influencing the participatory design practices. The *environment*, both cultural and physical, usually constrains the participation; for example, schools are considered as challenging environment due to factors such as strictly fixed schedules and a standard hierarchical structure teacher-students (Iivari and Kinnula, 2016). The *knowledge* and *skills* of the participants influences how participants view their ability to contribute and the actual ability to contribute; for example, children tend to have some difficulties to express their desires and are generally used to have roles subordinate to adults (Iivari et al., 2015; Lindberg et al., 2014). Finally the *security*, represented by several factors (e.g., emotional stability and stress), has an impact on how users participate. Considering these basic elements, according to the authors, children could be involved at different levels, from a simple evaluation of the products to a more structured participation as designers.

In this regard, Scaife and Rogers (Scaife and Rogers, 1999) introduced the concept of *informant* in an effort to move from the role of users identified by user-centred design, in the direction of a more participated design process. In their view children as informants cannot be equal partners, due to low available time and limited knowledge and expertise on the technological domain. Still, the

informants are considered fundamental stakeholders for the design process *"to help us problematize the domain, to test out and reflect on our assumptions and to evaluate our prototypes in real-world contexts."* (Scaife and Rogers, 1999).

Druin (Druin, 2002), similarly to the other authors, considered the participation as a necessary step in the design practices, emphasized by the gap (age, knowledge, skills, experience) between designers and stakeholders. Druin categorised the involvement of children in four roles - *users*, *testers*, *informants*, *design partners* - ordered by the level of participation. While users and testers are roles more tied to evaluation and testing, informants and design partners are actively engaged in the design of technologies. The informant, as conceived by Scaife and Rogers (Scaife and Rogers, 1999) is a first step for the empowerment of stakeholders, while the design partner represents the highest level of participation, where children are real peers taking decisions over the design as the other designers.

Beyond the reflections on the level of participation, and the commitment that such participation may require, recent research on games for purpose has many references to this need for involvement (Dodero et al., 2014; Khaled et al., 2014; Khaled and Vasalou, 2014; Moser, 2013). In the development of video games for purpose the quality of the design is decisive (Linehan et al., 2011). The purpose constrains the designers to mediate between the training or learning objectives and the ludic component, strongly influencing the final product. These issues should be faced in cooperation with the stakeholders. Even if the game designers know the full potential of the game, it is unlikely that they have the same perspective of domain experts and players, neither they can presume to know their capabilities and requirements. This gap leads to an incomplete view of the system that must be bridged to have a suitable product, where the application of participatory practices becomes a fundamental element for the design of games for purpose.

2.5. Video game development

Other works explored other perspectives on games for purpose, less focused on the participation of stakeholders. In the literature many works discussed the effectiveness of these products in terms of the purpose, as documented by various

reviews (Boyle et al., 2016; Dondlinger, 2007; Sitzmann and Ely, 2010; Wouters and van Oostendorp, 2013). A limited subset also devoted the attention to the game development, also reflecting on the problems encountered in the design process. As Moser and colleagues highlighted in a few occasions (Moser et al., 2013, 2014b), the research on the subject tends to show only the positive and simple side of development, marginalizing errors and problems. However, this information would stimulate a more structured discussion on the subject, and would support the development of new products allowing designers to enrich their work with the experiences of others.

Research works that critically discussed the issues of game development are quite limited. The literature, in most cases, lacks information on design process, structure and gameplay of the developed games (Laporte et al., 2013). In addition to some of the studies presented in section 2.4, other interesting experiences, less tied to participatory design practices, were collected in 2013 by Moser and colleagues (Moser et al., 2013). For example, Barendregt and colleagues (Barendregt et al., 2013) discussed several issues related to testing serious games with children in schools from a practical perspective. Their experience highlighted a need for meticulous planning of specific activities, such as recruiting and selecting the participants, but also of the design of specific features of the game (e.g., do not let the users delete their profiles).

Similarly, Duysburgh and Slegers (Duysburgh and Slegers, 2013) identified many problems strongly related to the design process. According to the users, working with children is a non-trivial task and the broad definition of this type of users highlights the gap between theory and practice. In theirs experience the main issues concerned the communication (with children and teachers) and factors related to the environment, such as noise, attention and concentration problems, inclination to influence and be influences by other participants.

De Troyer and colleagues (De Troyer et al., 2013) reflected more on the work of the researchers. Above the various requirements of the development process, they pointed out the need for a complete overview on the project, identifying precisely

the design space, the design goals and the people involved in the project in order to avoid any misalignment or misunderstanding. From a more practical perspective they highlighted the importance of the transfer of knowledge in the team managing the project and how this could influence the schedule.

In a similar effort, Vasalou and Khaled (Vasalou and Khaled, 2013) reflected on the limits of the development of educational games, particularly for European projects. There main concern was on the overall organization of the project and the relationship between designers and technologists. In their reflections they identified a few critical factors of this kind of projects. Firstly, design thinking tend to be subject to constraints, limited by technological requirements and the overall project proposal (e.g., the use of location-based functionalities). According to the authors, the problem could be overcome with a few precautions: to not constrain the project and the design space from the proposal; to define in first place the shared values of the researchers on the product and to determine the accountability of the various contributions; to set a shared language between members.

Hall and colleagues (Hall et al., 2013) focused more on the design of the game, criticizing a lack of challenge - defined as *"pleasurable stress the player feels as a direct result of the tasks that she/he needs to complete in order to reach a desired goal"* - in most of educational games. In their view, in most cases the game experience is tailored according to similar strategies employed in classroom (e.g., predictable and repetitive use of skills), limiting the potential of the digital artefact. Similarly, the critique raised by Maertens and colleagues (Maertens et al., 2013) was that educational games are too focused on the purpose and not on the design of the game. In this case, the authors identified specific parameters (e.g., gameplay mechanics, scenarios and quests, learner control) that should be considered to adapt the game experience, which are often neglected in similar projects. Still Maertens (Maertens et al., 2014) criticized a lack of clear findings in the effective outcome of serious games due to an infrequent interaction

between instructional design research and game design research, where the latter is usually considered subordinate to the former.

In a research field where the development of the product is crucial, these experiences represent a valuable resource. Some of these works have interesting reflections on the theoretical foundations of games for purpose, others present more practical aspects of the development. In any case, the various contributions could foster a broader discussion on this rapidly growing research topic, which requires such methodological and practical reflections. Many of the criticalities presented in this section (and in this chapter) will be found in chapters 4 and 5, and details will be provided on how these were managed and how they led to additional reflections. Certainly one of the purposes of this thesis is to describe another experience concerning the design of games for purpose, which together with the others could support the development of future projects.

3. CASE STUDY

The design process is usually the focus in the description of the development of a design artefact. However, this chapter describes in detail the background and the final outcome of the project (i.e., the video game). The design process will be presented in chapters 4 and 5. The reasons for this decision are twofold. The first reason relates to the philosophy of this work. One belief of the author is that in any research project related to game design the game should have the same importance as the process. The game is not just *a* medium to validate a theory: it is indeed *the* artefact that allows the validation of the theory. If a project aims at creating a video game for cognitive training, the goal is not solely the training, but the development of a playful artefact that supports cognitive training. The focus should not be strictly on the purpose, but on the entirety of the game; lacking a positive player experience (Nacke et al., 2010) would make it a product would not fit in the definition - section 2.2 - of game for purpose (Marsh, 2011).

The second, more pragmatic, reason is about the readability of the thesis: due to the length of the project, run over almost two years, the process is quite complex and long. Keeping the readers uninformed on the game would complicate the description of the various steps, and their consequences on the design. Similarly, informing the readers about the game during the description of the process, while providing information about the collected data and their consequences on the design, would have been quite complicated. Therefore, the game is introduced first, omitting any specific information about the process that led to the design of this final version, hoping that it will satisfy the curiosity of the reader and will support the comprehension of the various steps of the development of the game.

The chapter is structured in five sections. Section 3.1 introduces the cognitive training and the most significant research on the topic for this thesis, while section 3.2 gives an overview of the existing products in the treatment of dyslexia. Section 3.3 presents the background of the case study, describing the various actors, the purpose and rationale of the project. Sections 3.4 and 3.5 provides detailed information on the video game and its mini-games.

3.1. Cognitive training

Developmental dyslexia is the most common neurodevelopmental disorder across cultures (about 8-10% of children) and it affects children whose native language has irregular (e.g., English) and regular (e.g., Italian) orthography. These children struggle to read fluently and/or correctly even though they have IQs in line with those of their peers, normal reading education and no story of neurological or psychological problems. This condition not only affects students' academic achievements, but is also associated with several negative outcomes during lifetime.

Despite the considerable effort that has been devoted to identify the cause of developmental dyslexia, there is no agreement on a single proposal (Ramus et al., 2003). Furthermore, the investigation of the aetiological results is particularly complex and hard to disentangle, since this condition often coexists with other neurodevelopmental disorders, such as dysorthography, dysgraphia, dyscalculia and attention deficit hyperactivity disorder. From a neuropsychological perspective, the most compelling theory remains the phonological hypothesis, although empirical findings showed that these linguistic problems also interact with other cognitive deficits, belonging for instance to the executive system domain. In the last few years, growing evidences supported the multifactorial model: the neurocognitive developmental dysfunctions in developmental dyslexia might not be limited to linguistic deficits, but might also involve a combination of different impairments leading to the resulting difficulties in reading. In this regard, various studies documented a relationship between dyslexia and deficits in the Executive Functions (EFs), which can be defined as a cluster of general-purpose control mechanisms that modulate various cognitive sub-processes.

Several research projects showed that systematic and intensive cognitive training could improve a number of EFs such as working memory, attention, inhibition skills, mental flexibility and problem solving abilities (Dowsett and Livesey, 2000; Holmes et al., 2010; Klingberg et al., 2005). The enhancement of these cognitive skills is fundamental for a harmonious development of the child; for

example, a mature behaviour requires the ability to retain and manipulate information in the mind and to adjust the behaviour quickly and flexibly. Therefore, a functioning executive system should entail higher scholastic achievements, greater social skills and, more generally, a better quality of life.

Dowsett and Livesey (Dowsett and Livesey, 2000) discovered that preschool children, trained in inhibitory control, generalized their skills to non-trained domains (i.e. math skills); Holmes and colleagues (Holmes et al., 2010) found that working memory training had a positive effect on students' development in mathematics and problem solving. Klingberg and colleagues (Klingberg et al., 2005) demonstrated that children with attention deficit hyperactivity disorder improved working memory, inhibitory control and non-verbal reasoning ability by intense working memory training of 30 minutes per day across five weeks. Moreover, empirical findings suggested that children with learning disabilities might benefit from early intervention programs focusing on training EFs. For example, Gori and Facoetti (Gori and Facoetti, 2014) found that perceptual learning - an improvement of perceptual skills through exercise - could specifically improve visual abilities, whose impairment characterizes some neurodevelopmental disorders such as dyslexia.

These findings show the promising effects of cognitive training. However, the tools used for these trainings generally present some limitations. Firstly, they are designed to train single functions, even though the EFs work as a multi-dimensional system and it could be reasonable to include more than one EF in the intervention programs. Moreover, the existing tools are not particularly engaging and motivating. In this regard, the structure of a rehabilitative intervention should consider the emotional and motivational aspects, which often play a crucial role in determining the effectiveness of a treatment. An adequate level of motivation, particularly when intrinsic, would enable the achievement of broader improvements, increasing resistance to frustration. Considering young users, like in this case study, the type of activities could influence even more the compliance and the motivation, possibly affecting the outcome (Marotta and Varvara, 2013).

For these reasons, the training must consist of challenging and variable activities that require the user to be continuously committed in adapting their own behaviour, while creating a fair sense of competition through appropriate feedbacks. A direction that seems very promising (Franceschini et al., 2013; Green et al., 2010) is to design new rehabilitation products that while being based on a deep knowledge of neuropsychological theories also provide an engaging and challenging experience.

In this regard, Franceschini and colleagues (Franceschini et al., 2013) highlighted the fact that action video games could improve attention abilities and this improvement could be generalized to better reading abilities in dyslexic children. Their study provided the first evidence of the potential of video games in remediating learning disabilities. On these premises, the coexistence of a playful experience and an effective cognitive training seems a well-supported perspective for future research and development. Considering the need for a more complete and more motivational training, games for a purpose could be a suitable solution, both for researchers and for children.

3.2. Existing products

In addition to the studies on dyslexia and its possible treatment through cognitive training, it is necessary to provide an overview of products that are currently used in this context. For example, the digital tachistoscope is a rehabilitative tool for reading disorders. The interaction consists of a quick and timely reading of words: the system proposes a series of words, shown individually in rapid succession, that users must read aloud. During the years, a variety of studies have supported the use of the tachistoscope asserting that the fast stimuli presented by the system would positively influence correct (and fast) reading of words, a skill that could be easily transferred to the reading of texts.

Compensative tools also widely used by dyslexic children are text-to-speech programs. These products turn text into spoken language, and are recommended for children and teenagers with low reading skills that, due to the slow reading and the high error rate, have a partial and often fragmented comprehension of

texts. A proper use of these programs stimulates autonomy in reading and studying, and a consequent improvement in self-esteem given by the possibility to independently handle the disorder.

Conceptual mapping software is another compensative tool for dyslexic children. These programs are particularly useful for organizing content according to hierarchical relationships and linking different information according to specific criteria, generating maps of knowledge. Conceptual maps are used by dyslexic students to reorganize information, analyse complex situations, and support problem solving activities.

Finally, other commonly used tools are programs for creating and managing digital diaries. Developmental dyslexia does not only affect reading and writing skills, but other cognitive activities such as time management. Dyslexics struggle to have clear planning of the daily activities and allocate sufficient resources. Digital diaries, similarly to conceptual maps, support the consolidation of ideas, in this case useful for a better organization of time and a more efficient management of activities.

The description of these products highlights the fact that their design is usually focused on the training and/or compensative aspects, placing entertainment in second place. These kinds of solutions are developed to support users and not necessarily to entertain them; some versions propose gamification (e.g., badges) features, still usually subordinate to the purpose of the tool.

Cognitive training applications are another type of product strictly related to the case study. In recent years, the cognitive training market has grown considerably, offering various solutions for users interested in improving their cognition. Without going into detail about all existing products, some have distinguished themselves in the market, and are an excellent representation of the offer.

Dr. Kawashima's Brain Training is one of the first largely used examples. Introduced for the first time in Japan in 2005 as one of the launch titles of the handheld console Nintendo DS, the game offered a series of exercises on memory

and calculus. Following the commercial success of this game, other companies have proposed cognitive training products, offering solutions more or less engaging and not always sustained by scientific validations (Simons et al., 2016).

Nowadays, some of the most famous titles on the market are BrainHQ, Lumosity, FitBrains, Cognifit, which offer broad databases of mini-games and exercises aimed at training various EFs. As discussed in section 3.1, these products are designed for a generic audience (e.g., Dr. Kawashima is one of the titles that marked Nintendo's direction toward casual games); similarly, the structure of the proposed trainings is usually quite generic, with the risk to be less effective when applied as in this case study to specific groups.

3.3. Design rationale

The project started in January 2015 as collaboration between the Department of Information Engineering and Computer Science (DISI) and the Laboratory of Observation, Diagnosis and Training (ODFLab) of the Department of Psychology and Cognitive Science, both of the University of Trento. On the side of the ODFLab the project was motivated by a previous research on cognitive training (Pasqualotto and Venuti, 2014). The experimental study involved a group of nine dyslexic children aged between 8 and 14 years old. The training was administered via BrainHQ, a leading computing tool supported by solid neurocognitive research.

BrainHQ is a web-based platform that proposes similar exercises to clinical practices and incorporates some aspect of gamification, such as a scoring and rewards by means of stars and badges. As similar products, the platform is targeted to a generic audience and is mainly oriented to the training aspects than the entertainment ones.

Children were given a training program distributed over five weeks, which required them to exercise 30 minutes a day for five days a week. The exercises changed weekly, logs were tracked, and each child was tested pre and post intervention. Even if the training was short, its effect was strongly positive: the

participants showed a significant improvement in attention and working memory, inhibition ability, visual-motor integration skills, cognitive flexibility and fluid intelligence. Regarding dyslexia and reading/writing skills in relation to the literacy of the participants, significant improvements resulted in the accuracy of reading. The follow-up, held after six months, showed a general maintenance of the post-training performance.

This positive framework was counterbalanced by several complaints by children and parents. If on the one hand the computer-based intervention immediately appealed to most of them, BrainHQ was soon considered boring and difficult. Thus the training had to be enforced by the parents and was considered by the children as a homework more than a diversion. This attitude is well exemplified in the words of a child participant (age 10): "*It was terrible. I don't know if I would rather prefer to do this again or my math homework*". The appeal of the gamification elements quickly vanished for most of the children, whereas the performance anxiety induced in some of them tended to last. Overall, the interactive system appeared to be incapable to motivate them.

The experience with BrainHQ showed the great potential of cognitive training; however, it also highlighted the need for a stronger game design in order to provide an engaging experience. To overcome the motivational barrier, DISI and ODFLab agreed on a project aimed at the development of a game for purpose for cognitive training. For ODFLab the collaboration would have empowered the cognitive scientists to take decisions over the design in accordance with their work practices in the clinic. For DISI, especially for the author of this thesis, the management of the project would have allowed to study on the frontline the design process for games for purpose.

In this regard, there are various implications, including practical ones, that well suited the project. First of all, the potential collaboration with domain experts and players, coupled with the availability of designers with programming and artistic skills, met the basic requirements in terms of team and stakeholders for the development of the video game. Moreover, the involvement of children as players

was perceived as a challenging and stimulating factor. Starting from the experiences of other researchers - e.g., (Iivari and Kinnula, 2016; Khaled and Vasalou, 2014; Moser et al., 2013) and other works discussed in sections 2.4, **Error! Reference source not found.** - the designers had the chance to extend this complex research topic, applying the solutions developed by others, and documenting their own experiences and reflections.

The freedom of management was another element that came in favour of the project. Without specific deadlines, the team would have had enough time and resources to devote to the overall development of the game, without sacrificing some parts due to potential limits set by the arrangement of the project (De Troyer et al., 2013; Vasalou and Khaled, 2013).

Finally, another important factor was the purpose of the project. The experimental aspect of the product, provided sufficient flexibility in working with the domain experts without being constrained by too restrictive requirements. Considering a case study with restrictive requirements, the game design space would have been too limited, risking to develop a product far apart from the author's ideal of a game for purpose (Marsh, 2011).

3.4. Skies of Manawak

The final outcome of the project was the video game *Skies of Manawak*. The description of the game is articulated over four subsections, which are structured according to the elemental tetrad (Schell, 2014). The first subsection presents the general plot. The second one describes the visual aspect of the game and its setting. The following subsection outlines the mechanics, while the last one presents the technological space. The descriptions do not provide technical details (e.g., programming code); even if these were important for the development, they are not instrumental to the understanding of design. The aim is to provide enough information to have a general overview of the game, without overwhelming the reader with too specific details.

Skies of Manawak relies on a literary language to identify specific entities within the game world. The author decided to use the keywords of the language in the following descriptions for consistency with aesthetics and story. For ease of reading, the words and relative meanings are listed below:

- *Manawak*: the planet where the story takes place, but also the gravitational anomalies surrounding the planet;
- *Rakus*: giant flying creatures that inhabit the Manawak;
- *Hoa'manu*: the guardian of the Rakus. A title given to the protagonist at the beginning of the game;
- *Ukas*: shamans, capable of performing the ritual for calling the Rakus;
- *Rekenanangi*: the ritual for calling the Rakus;
- *Kivas*: hi-tech towers used in ancient times to control the gravity of the planet and now sacred temples.

3.4.1. Story

The general plot of Skies of Manawak is set on a planet in another solar system. The population colonized the planet thanks to a terraforming process that made it habitable. Centuries ago, a cataclysm caused the dysfunction of the gravity generators, causing diverse anomalies that disrupted the entire planet. The cataclysm resulted in a surreal scenario where entire continents lifted off the ground and started floating hundreds of meters above a land submerged by the seas. After centuries of survival the descendants, oblivious to their own origins, live peacefully in various villages spread across the planet. One day invaders from outer space descend on the planet and start to reactivate the ancient towers containing the gravity generators, the Kivas, now considered sacred temples. The floating lands then begin to collapse, jeopardizing the fate of the planet.

The game begins on the day of the initiation of the protagonist: the girl/boy (the player can choose from a roster of different characters) is awarded the role of Hoa'manu, the guardian of the Rakus, creatures able to glide in gravitational anomalies called Manawak. Flying through the various nations and facing a number of challenges, Hoa'manu and its Raku must deactivate the Kivas to stop

the collapse of the floating nations. During the journey, they will face the invaders and will finally understand the reasons why they attacked the planet.

3.4.2. Aesthetics

The visual style of Skies of Manawak resembles the illustrations of children's books. Except for a few elements (e.g., trees), the graphics were completely designed by Adriano Siesser, MA at Accademia di Belle Arti di Venezia, from the first sketches to the final appearance of the game (Figure 2 and Figure 3).

The visual representation binds to a fantastic setting, but it is inspired by real elements, creating a consistent game world. The characters have a non-caricatured human aspect; the look of the Rakus resemble animals such as birds and dinosaurs; the enemies have a minimalist robotic appearance, which is based on simple geometric shapes, mostly circles and triangles.

The various game scenes are in 2.5D, where two-dimensional graphics techniques are applied to create the illusion of three-dimensionality. The movement of the character and most of the other game elements is two-dimensional, oriented on the X and Y-axis of a Cartesian space. The objects, however, can be positioned in different points of the Z-axis: the clouds, for example, move from left to right on a horizontal line, but are generally placed at different depths and heights. This

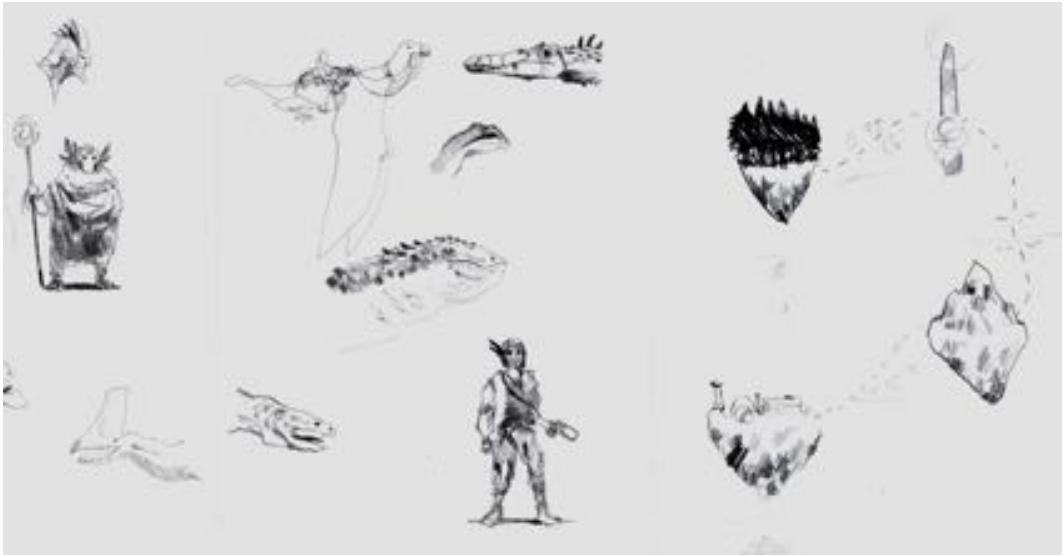

Figure 2. First sketches of Skies of Manawak, portraying the Uka, the Rakus and Hoa'manu.

Figure 3. An in-game screenshot of the village of the forest (upper part) and a flight session in the nation of glaciers (lower part).

management of space and movement creates a parallax effect (e.g. clouds in deeper positions seem to move slower), giving a sense of depth to the space of the game and creating a richer representation of the world (Figure 4).

In general, the game world is inspired by the Sci-Fi genre, which was found to be preferred by the target audience probably due to the commercial success of several examples in the entertainment market in recent years. Examples of worlds

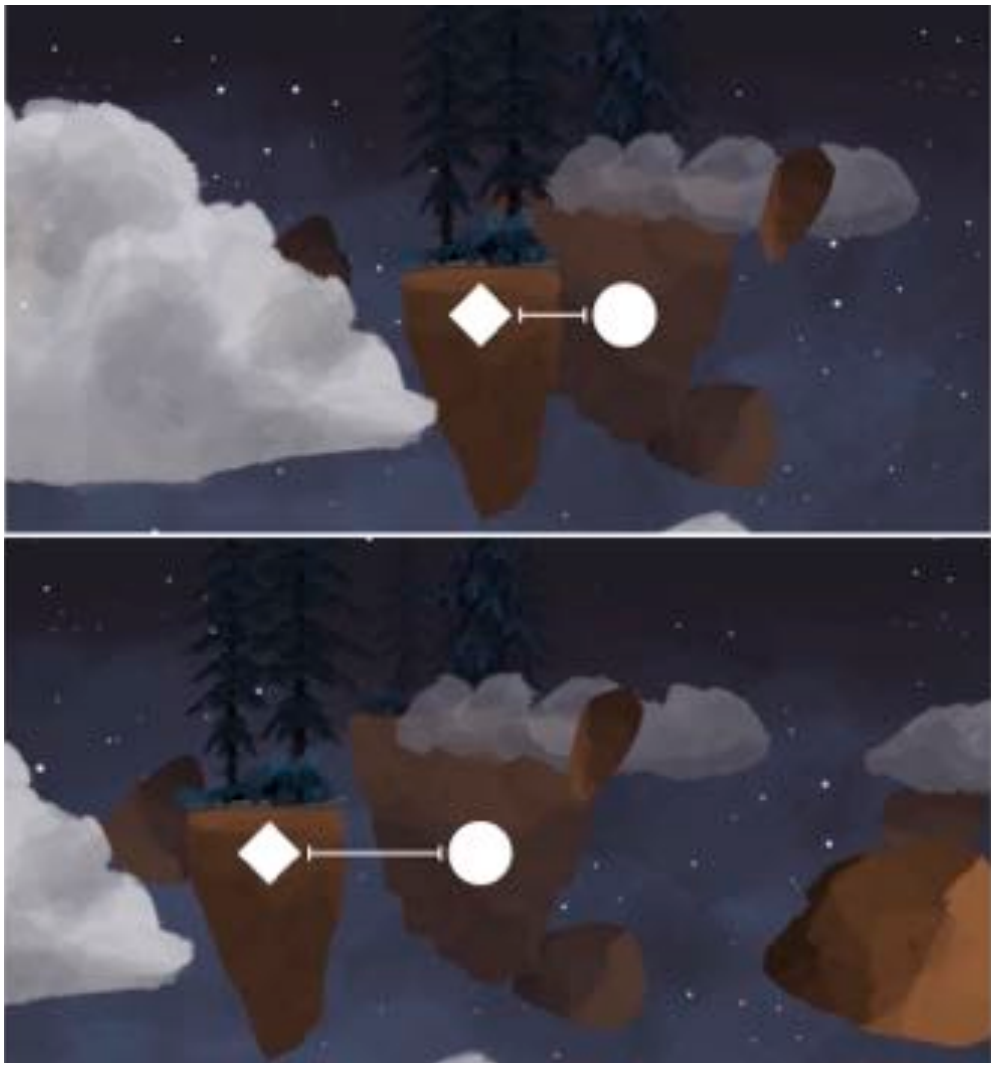

Figure 4. Parallax example: the two screens were taken a few seconds away; the island near to the camera (diamond) appears to move faster than the distant one (circle).

in which nature and technology are combined in surreal scenarios can be related to Star Wars, Star Trek or Avatar. The Sci-Fi theme allowed the creation of scenarios where highly technological environments alternate with various lands (e.g., forests, desert and glaciers). The variety of environments enriched the design of Skies of Manawak with the aim of enhancing the immersion and stimulating the curiosity of the players.

The main characters are designed with no particular gender characterization and no specific age (Figure 5). The player can choose between a few characters based on the aesthetics of hair and clothes; other than this, the look is quite neutral. This

Figure 5. The roster of main characters of the game. From left to right: a boy from the forest's nation, a boy from the glaciers' nation, a girl from the sea's nation.

roster of not overly characterized boys and girls was developed to give the possibility to players to choose a character in which they could identify.

Another feature is a symbolic language that was developed for the game (Figure 6). The use of a symbolic language supported the definition of the setting: on the planet, the population has its own vocabulary. From a game design perspective, the symbols were also useful for the creation of the mini-games, used as input and output for the puzzles (e.g., find a specific combination of symbols to hack the system). Similarly, some words were invented - for example Manawak was inspired by Native American languages - and used to create the feeling of a common language shared within the game world. In line with symbols and language, the appearance of the characters follows this tribal theme (Figure 7), strengthening the consistency of the setting.

The aesthetics of Skies of Manawak also concerns the sound design. The soundtrack features three main audio tracks, alternated in the different game scenes. The first track, with a very slow and relaxed tempo, is played in scenes such as villages or menus; the second one, more rhythmic, is played in mini-games with a high level of action, where the player must run, jump and/or shoot; the third track, with an electronic tone, is played in technological environments,

Figure 6. The symbols of the six nations of the planet Manawak.

such as the Kivas. All the dialogues in the game are dubbed for ease of reading for players; the recordings have an equal distribution between male and female voices, maintaining gender neutrality.

3.4.3. Mechanics

Skies of Manawak is subdivided in mini-games integrated in the story. Every time the player reaches one of the villages the chief assigns a new quest. In order to start a new quest, the player must go to the Uka of the village and must perform the Rekenanangi, a mini-game used for calling the Raku. Every mini-game has its own set of mechanics that will be described in detail in section 3.5.

The game is characterized by a modular development of the story; in other words, even if some events are strictly related to the main plot, everything else is generated at run-time according to the performance of the player. Usually the quests have a generic structure. First, Hoa'manu receives a new mission from the chief of the village and it goes to the Uka to perform the Rekenanangi. During the quest, Hoa'manu and its Raku go through a set of mini-games (sub-quests). Then,

Figure 7. Some of the NPCs populating the village of the desert. From left to right: the merchant, the Uka, the chief of the village and a common villager.

they reach one of the Kivas, where Hoa'manu solves a few puzzles and turn it off. Finally, they go back to the village and if all the Kivas nearby are deactivated, the chief sends them to a new village. In this structure the fixed points are the villages and the Kivas; the sub-quests that the player must face are determined and generated by the system. Every mini-game is designed to train a specific EF and the set of mini-games of a quest is determined by the player performance and the training path.

Figure 8 provides a simplified representation of these mechanics. If in the previous quest the player strongly improved in the mini-games on response inhibition, but had a low performance in split attention, the system generates a new quest that is structured through a path *a, d, e, f* (yellow path: village, first action session, split attention, second action session, working memory); vice versa, if the player improved in split attention, but had a low performance in response inhibition, the system generates a path *a, b, c, f* (red path: village, first action session, response inhibition, second action session, tower); if the player had general low results, the system generates a path *a, b, c, d, e, f*; finally, if the player had general high performances, the system generates a path *a, f* (green path) and postpones the mini-games on response inhibition and split attention in the quest after the current one.

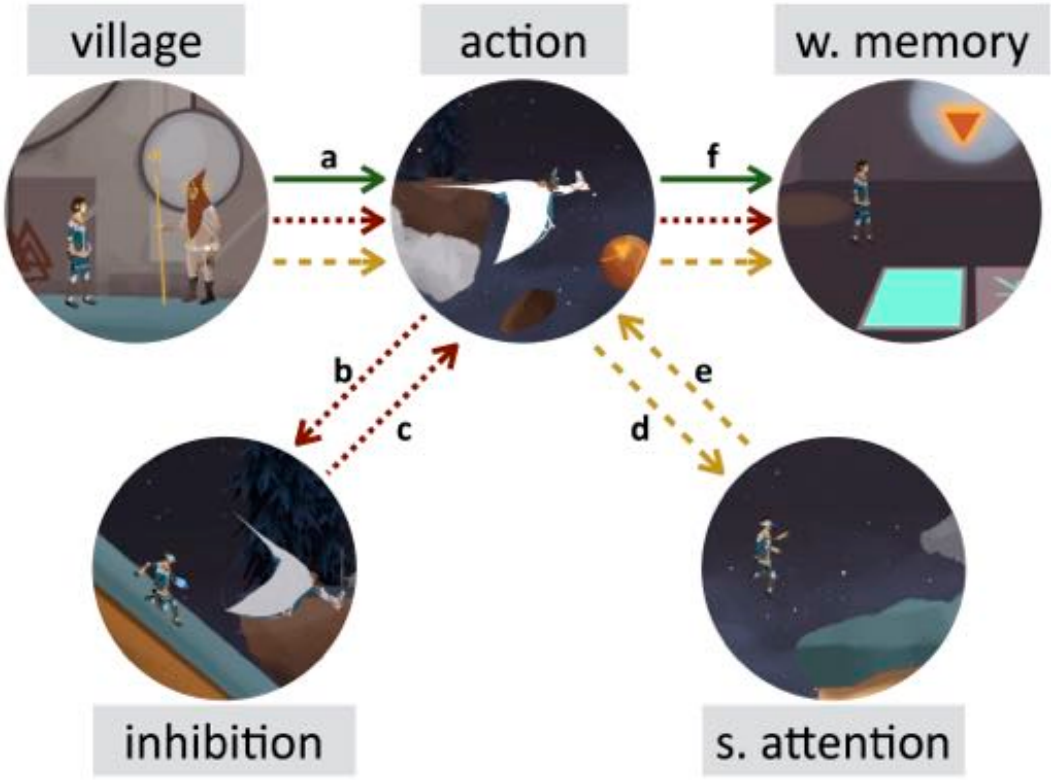

Figure 8. Example of the ramification of the quests according to the performance of the player.

Similarly, the system automatically balances the difficulty of the mini-games. Every parameter (e.g., errors, duration and trials) of every mini-game is registered at run-time. Based on the performance registered on a specific mini-game the system balances the difficulty of the next sub-quests. Considering a player with low performances in split attention and high performances in inhibition mini-games, the former will be more frequent and with a low difficulty, while the latter will be sparse but more challenging. In this way the structure and overall difficulty of a quest is suitable to the player, always maintaining a minimum level of challenge to keep the immersion (Cox et al., 2012).

In Skies of Manawak there is no game over screen. Hoa'manu cannot die and even if the player does not perform well, the game still has a progression: in some cases the player must to go through an intermediate mini-game in order to recover some life points; in other cases she/he restarts from a checkpoint (i.e., not from the beginning of the sub-quest); in short sub-quests, she/he has to repeat the mini-game. In case of repeated fails the system usually provides support through a

spirit guide, which constantly follows the player suggesting part of the solution of the mini-game. The reasons for this design choice are twofold. The most important is that the game should provide a training path. The player should play various mini-games and any chance to be stuck at a specific point in the game should be avoided. The second reason concerns the psychological attitude of the players. Being targeted to various types of players, not only diversified by age, but also by skills, the system provides a smooth experience for everyone, with low chances of creating stress and frustration. These balancing strategies are not only aimed at avoiding negative outcomes, but to adapt the experience to different skills, contributing positively to the gratification and self-esteem of players (Gerling et al., 2014).

The game has a reward system that is activated at the end of every mini-game. The reward is aimed at providing a feedback to the player about the performance and stimulates challenge: the better they play, the better they are rewarded. This system is balanced to avoid any response of frustration; even with the lowest performance a small reward is guaranteed. The system provides a scoring, from half to three *eagles*, and a set of resources (Figure 9).

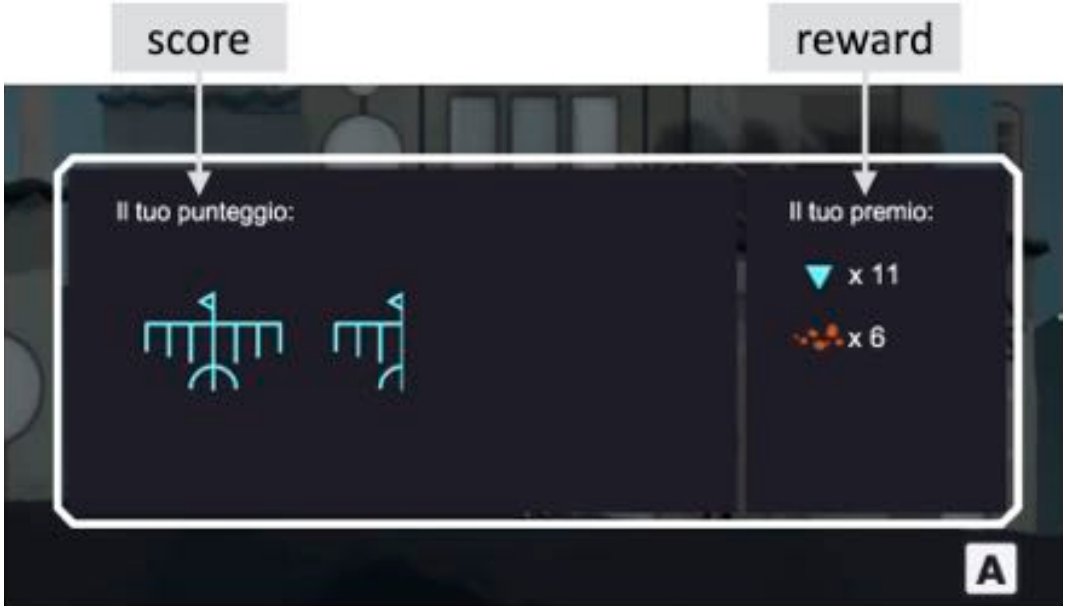

Figure 9. The reward game screen, showing the score (left part) and the reward (right part).

The resources are of four kinds, namely *tetrads*, *rust*, *silver* and *gold*. Tetrads are the currency used on the planet and can be collected and spent during the whole adventure. The other materials can be collected during different phases of the game. Based on the progression, the players gather new resources, where rust is the most common and gold the rarest. These resources are used to unlock better upgrades.

In every village a merchant provides upgrades that could be unlocked to improve the statistics of Hoa'manu and the Raku (Figure 10). With better statistics, such as better attack or defence, the player is supported in the progression of the game, with better chances to increase their perceived performances (a stronger character does not imply being a skilled player) and discover new game elements (e.g., new more powerful enemies).

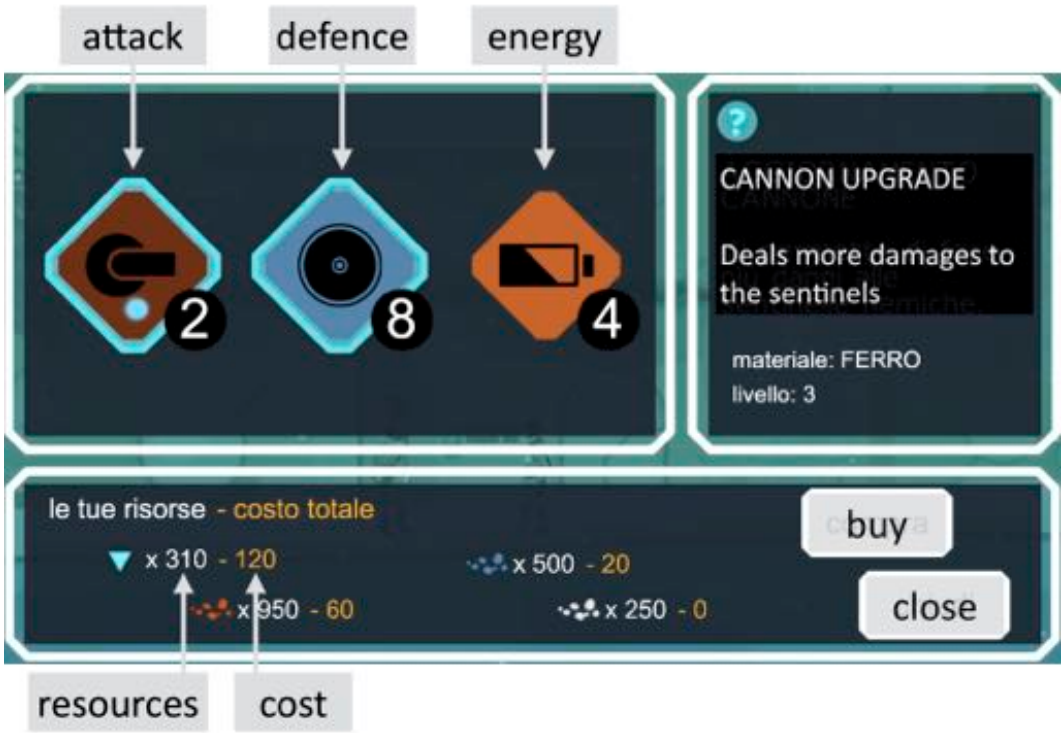

Figure 10. The merchant game screen, showing the upgrades (upper left part), the description (upper right part), the cost and the available resources (lower part).

3.4.4. Technology

Skies of Manawak was developed using Unity3D, an environment oriented to visual manipulation: the game elements can be added and partially modified through a visual interface that provides a faithful preview of the look and feel of the game. Technical parts, such as the scripting of the behaviour of non-player characters, were developed using MonoDevelop, an integrated development environment for C# and JavaScript. The high-level editing provided a simple and intuitive representation of the game, which - as it is be described in detail in chapters 4 and 5 - supported a non-technical communication between the members of the development team.

Unity3D supports cross platform development, meaning that video games can be built as web, computer or mobile applications. Skies of Manawak was released for computers on the most common operating systems (i.e., Windows, macOS, Linux). The release as web application was discarded since the beginning of the project due to technical limitations. In Italy, where this research took place, a fast internet connection is not a predictable household service. This problem could have been overcome by sacrificing the quality of the game, resulting in less rich aesthetics with low quality images and sound. Moreover, the design process included the intervention in various schools and not all institutes had an internet connection in their computer labs. The development for mobile platforms was planned as next step of the research, and it was not set as a priority until the release and evaluation of the computer version.

The development of Skies of Manawak obviously required a substantial amount of work from a technical perspective. Tens of thousands lines of code were written and re-written, hundreds of images were drawn and dozens of sounds and voices were recorded. The details are out of the scope of this manuscript and will not be explored further; however, some reflections and criticalities related to the technology will be discussed in the following chapters.

3.5. Mini-games

Skies of Manawak can be deconstructed into *scenes*, a terminology used in Unity3D that refers to elements such as main menus, loading screens and game levels. The scenes of Skies of Manawak can be roughly divided in: villages, where the player can gather information, buy new upgrades and receive new missions; mini-games, which represent the sub-quests structuring a mission. The game contains ten different types of mini-game, each one training one or more EFs (Table 1). The following subsections present them, providing information in terms of the story, the mechanics and the specific purpose. The mini-games in which the clinical counterpart is not explicitly described were not extrapolated from specific exercises, but from research in cognitive science.

Table 1. The mini-games of Skies of Manawak (left column) and the related EFs (right column).

mini-game	**trained EFs**
Rekenanagi	• working memory on visual stimuli
The flight	• visual sustained attention • visual selective attention
Fishing	• visual selective attention
Kiva - the security system	• working memory on visual stimuli
Kiva - the energy system	• planning
The call	• working memory on auditory stimuli
The falling island	• response inhibition on visual stimuli
Meteors and islands	• visual divided attention
Secret island - the shell game	• visual selective attention
Secret island - the shooting gallery	• visual sustained attention • visual selective attention

3.5.1. Rekenanangi

Every time that Hoa'manu needs to call the Raku to reach the next Kiva, it must perform the Rekenanangi. The ritual is structured in a few steps (Figure 11). First, the shaman summons a series of symbols (Figure 6), one after the other. An algorithm decides randomly which symbol is summoned next. The length of the combination is based on the difficulty of the game, but keeping a percentage of uncertainty. As shown in Table 2, an easy level of difficulty could have series composed by a minimum of three to a maximum of five symbols. The persistence of each symbol and the waiting time between one and the next is also based on the difficulty. A medium level would have 1 second of persistence for each symbol and a waiting time of 0.15 seconds; a combination set to five elements would take 5.6 seconds (= 1s x 5 + 0.15s x 4) to show all the symbols.

After the first part of summoning, the player has to answer selecting the last *n* symbols of the series. The *n* is determined according to the difficulty and notified to the user using a visual clue (grey circles in Figure 11) at the beginning of the ritual. As shown in Table 2 and Figure 11, a hard level would require the player to answer by identifying the third to last, the second to last and the last symbol.

Table 2. Information on combination and persistence, and examples of answers for the Rekenanangi in relation to the difficulty.

difficulty	combination	persistence	answer
easy	from 3 to 5	2 seconds (+ 0.25)	last symbol series: fogs, forest, plains answer: plains
medium	from 4 to 7	1 second (+ 0.15)	last two symbols series: fogs, forest, plains, sea answer: plains, sea
hard	from 5 to 10	0.4 seconds (+ 0.05)	last three symbols series: fogs, forest, plains, sea, fogs answer: plains, sea, fogs

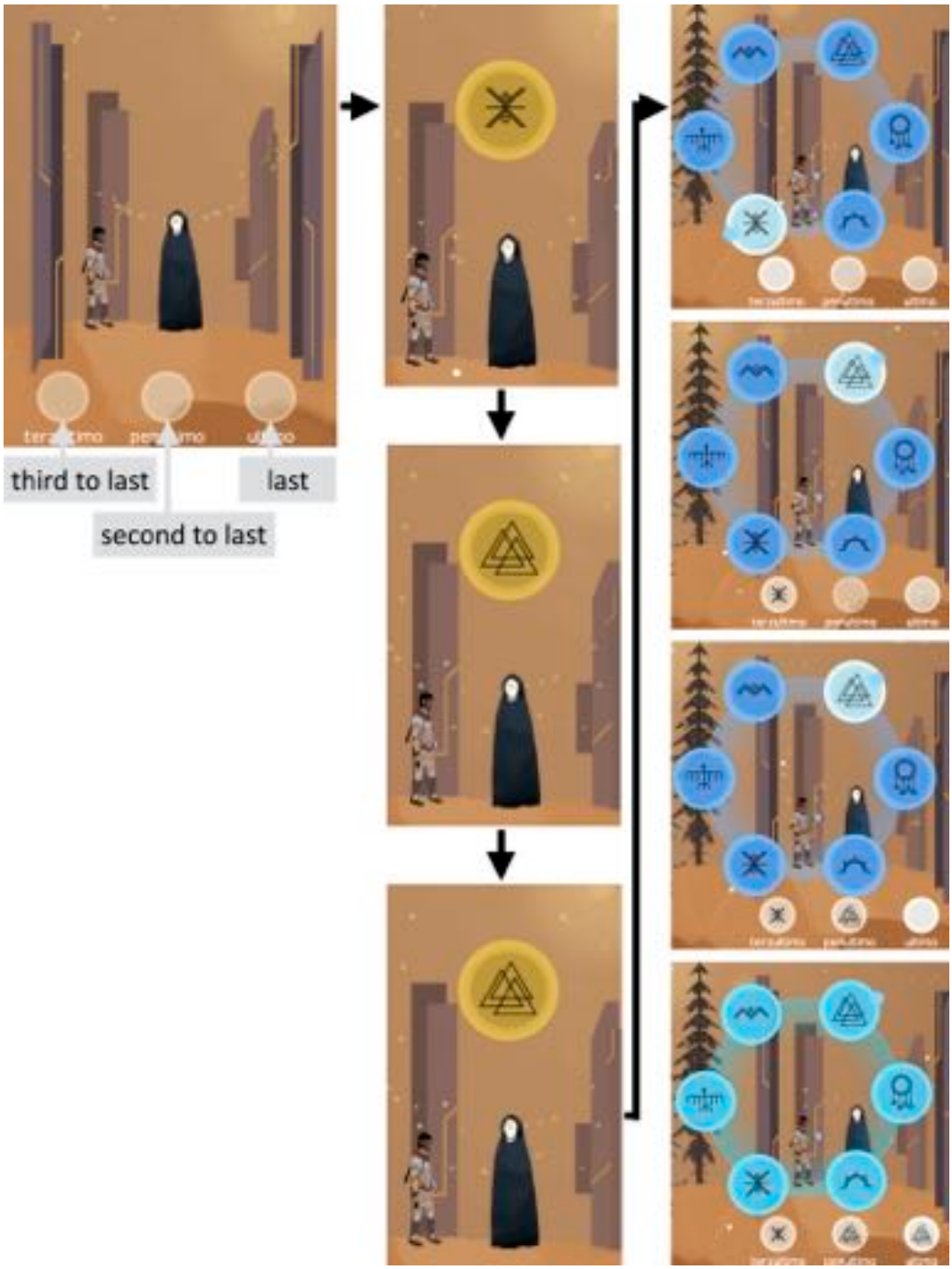

Figure 11. A session of the Rekenanangi: the Uka starts the ritual and shows the combination (left and central columns); Hoa'manu repeats the combination (right column).

The system requires the player to answer three combinations correctly out of five before moving to the mission. If the player wins with no mistake, the system registers the performance and increases the difficulty for the next time; if the player wins with one or two mistakes, it keeps the same difficulty; if the player gives three wrong answers, the shaman interrupts the ritual, the difficulty is lowered, and the player has to perform a new ritual. The system provides support for repeated fails: the spirit guide intervenes suggesting part of the solution.

The Rekenanangi was designed to train the working memory based on visual stimuli. The player has to keep track of the symbols shown, working on the short-term memory; in addition she/he has to elaborate this information, for example creating a mental register, and continuously add-remove the elements of the combination. In a clinical setting the process is quite similar: the exercise presents a list of letters or numbers (instead of symbols) of undefined length. The participant has to repeat the last *n* elements, usually three, of the series.

3.5.2. The flight

After Hoa'manu completes the Rekenanangi, it reaches the sky flying on the Raku (Figure 3). The main objective of the mini-game is to reach another place in the game world, like an island where the main character must rescue a lost villager or a Kiva to deactivate. The sky is populated by threats of different types.

The simplest are the environmental obstacles in form of flying stones and boulders. The stones appear on the game screen in masses of multiple elements, moving horizontally from the right boundary to the left one (Figure 12, upper part). The boulders appear as small groups of elements and move in the three-dimensional space from the depth of the screen in the direction of the camera (Figure 12, lower part). The player has to evaluate the movement of the various obstacles and dodge them by moving the Raku.

The *sentinels* are the main threats during the flight sessions. The sentinels have different appearances, behaviours and statistics depending on the type (Figure 13). For example, the basic sentinels are made out of rust (the basic resource of the game), move on a straight line, cause low damage and can be destroyed by a

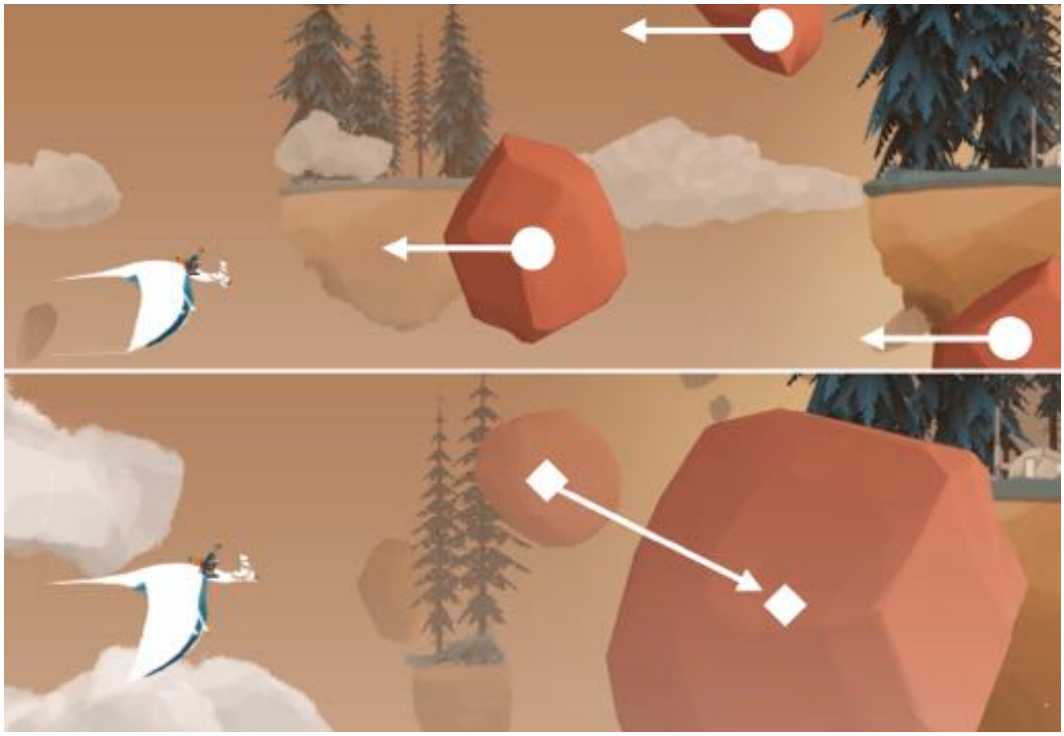

Figure 12. Two flight sessions showing a cluster of meteors (upper part) moving toward the Raku, and boulders (lower part) moving toward the camera.

single bullet; the bombers are cluster of gold sentinels that partially follow the trajectory of the player and shoot energy bombs: they cause huge damage and each one can be destroyed by two or three bullets. The player can both dodge and shoot them; based on the type, each sentinel releases some resources when destroyed.

Finally, the most powerful enemy is the *phoenix*, an ethereal creature with the shape of a bird (Figure 13). The phoenix can change shape and pattern of attack, and a battle can last a few minutes due to the high health points. The player must use mixed tactics of dodge and shoot in order to survive and destroy it.

Every time the Raku is hit, it loses some health points. If the health points reach the zero, the Raku goes fishing to recharge the energy (subsection 3.5.3). As consequence, the player will receive a smaller final prize. The system generates the different threats according to the level of difficulty, which is based on the previous performances in the sky sessions. The meteors and boulders change in speed and density of the clusters; the sentinels change in type; the phoenix has a

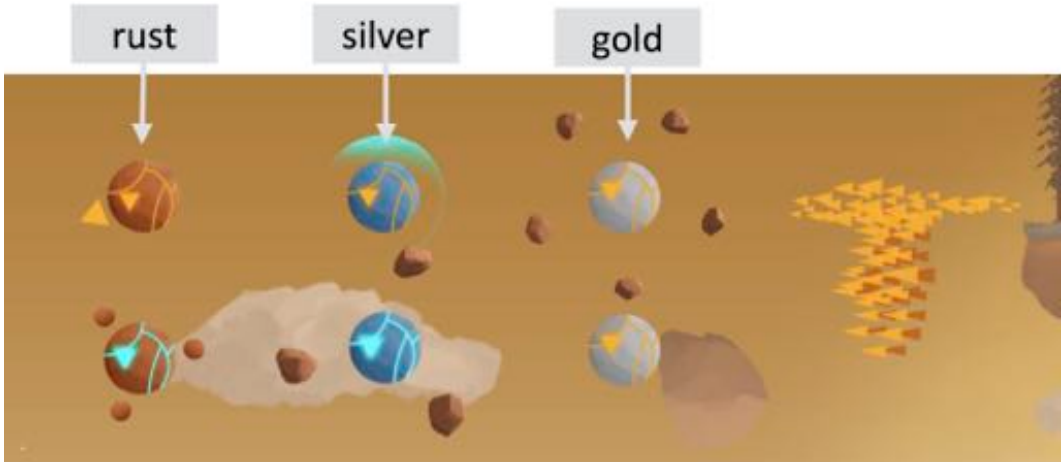

Figure 13. Some of the sentinels populating the skies of Manawak and a phoenix (right-most column).

different probability to appear, with a maximum of one phoenix per session (i.e., at low levels of difficulty the player has no chance to encounter it). The system can also generate power-ups to support the player, providing a temporary boost to the attack or defence. The mini-game is completed when the Raku reaches a Kiva or other points of interest.

This mini-game is the most experimental from the perspective of cognitive training. Its design in these terms is based on the research of Franceschini and colleagues (Franceschini et al., 2013) and other studies (Eichenbaum et al., 2014; Green et al., 2010) on the effect of action video games on EFs. The game provides different types of stimuli, which occupy both the central and peripheral vision; the player must constantly change action strategies and must have a quick response to the continuous change of the game elements.

The flight sessions were designed to train the visual sustained and the selective attention. The visual sustained attention concerns the readiness to detect unpredictable visual signals over prolonged periods of time. The visual selective attention refers to the process of discrimination of specific objects in the environment for a certain period of time, filtering less relevant details.

3.5.3. Fishing

Whenever Hoa'manu and the Raku reaches zero health points during the flight, they glide to the surface of the sea to gather food and recharge the health points. The fishing procedure is based on three steps (Figure 14). Firstly, one fish appears on the screen, indicating the prey selected by the Raku. Secondly, other identical fishes appear and the group starts to shuffle. At the end of the shuffling, the player has to select the fish that appeared first on the screen.

The persistence of the first fish, the total number of fishes, the number and speed of the shuffles is based on the difficulty of the level. The system creates a minimum of five iterations and each correct catch recharges 20% of health points. The system requires at least one correct catch: if the player gives the wrong answer for the first five iterations, the mini-game continues until a correct answer is given. Five correct catches will result in the full recharge of the health points and an increase in the difficulty level. One correct answer will take to a decrease of difficulty; else the system will maintain the same difficulty.

The fishing session was inspired by the *shell game*, or similar gambling games where three or more identical objects are placed on a surface. One of the objects hides a ball, and the player has to locate the position of the ball after a series of shuffles. The focus of the player is on the discrimination of the right object from the other identical ones; the fishing session was designed to train the visual selective attention.

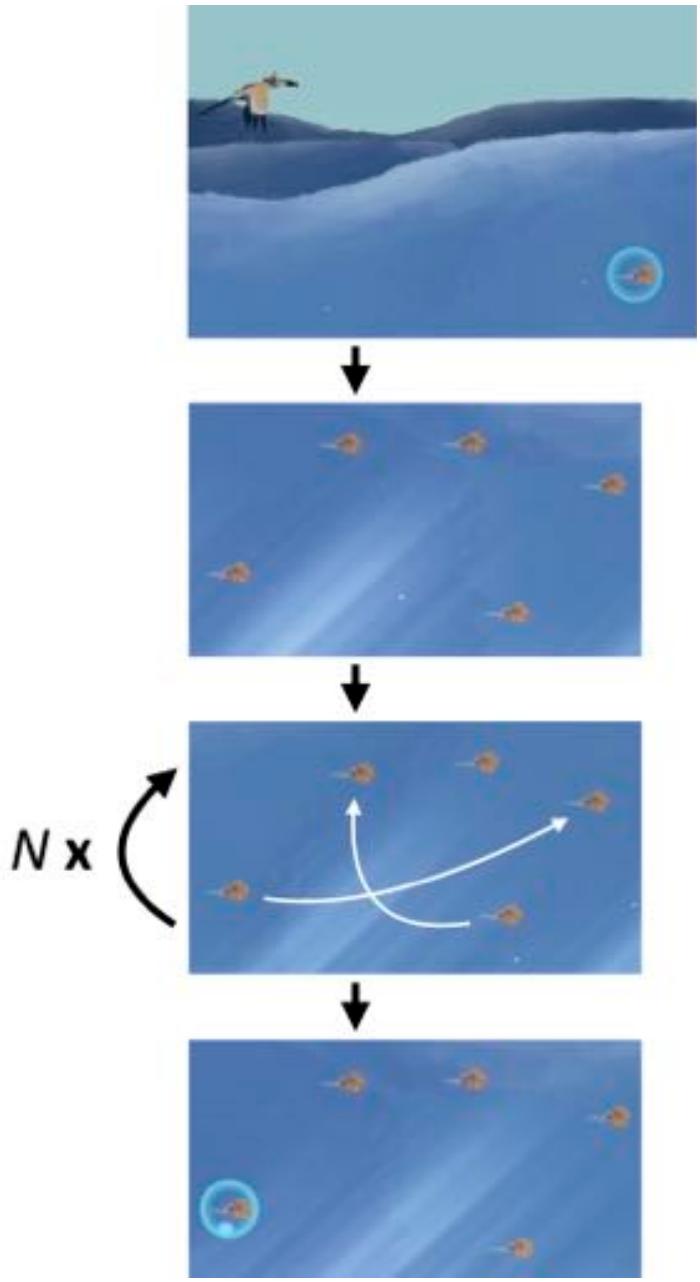

Figure 14. A fishing session: the first nautilus appears; it is shuffled with the others; finally, the player has to identify the correct one.

3.5.4. Kiva - the security system

When Hoa'manu enters a Kiva, it automatically activates the security system. Hoa'manu must find the right combination for every room to access the elevator, reach the last floor, where the energy panel is located, and deactivate the tower. The combination is represented on a matrix of tiles placed at the centre of the room; based on the difficulty, the tiles can form a two by two or a three by three matrix (Figure 15). The combination is shown in two steps. Firstly, every tile shows a symbol; secondly, the symbols disappear and the tiles are lit up, one by one, forming a path. The player has to recreate the combination moving Hoa'manu on each tile, following the specific path and identifying the corresponding symbol.

The persistence of the symbols and the path lighting speed are determined by the difficulty of the level. The player must solve three combinations in order to win the game. A combination is solved when the player provides the right answer for every tile; if she/he gives one wrong answer the main character moves to a corner of the room and the puzzle restarts. Every time the player solves one combination the difficulty increases; the opposite effect applies in case of wrong answer. If the player makes three mistakes the main character is teleported to the first floor and she/he has to replay the entire mini-game. In case of multiple fails, the spirit guide intervenes providing visual clues on the right combination.

The security system was designed to train the working memory based on visual stimuli. Even if the mechanics differ from the Rekenanangi (subsection 3.5.1), the EF is the same. The player has to keep track of the displayed symbols and the path, working on the short-term memory; in addition she/he has to combine these two pieces of information to find the correct solution. In a clinical setting the exercise presents a table of letters or numbers, then the table is substituted by a new one showing a series of arrows underlining a path. Finally, the participant has to fill an empty table with the elements showed in the first table and following the order of answer shown in the second table.

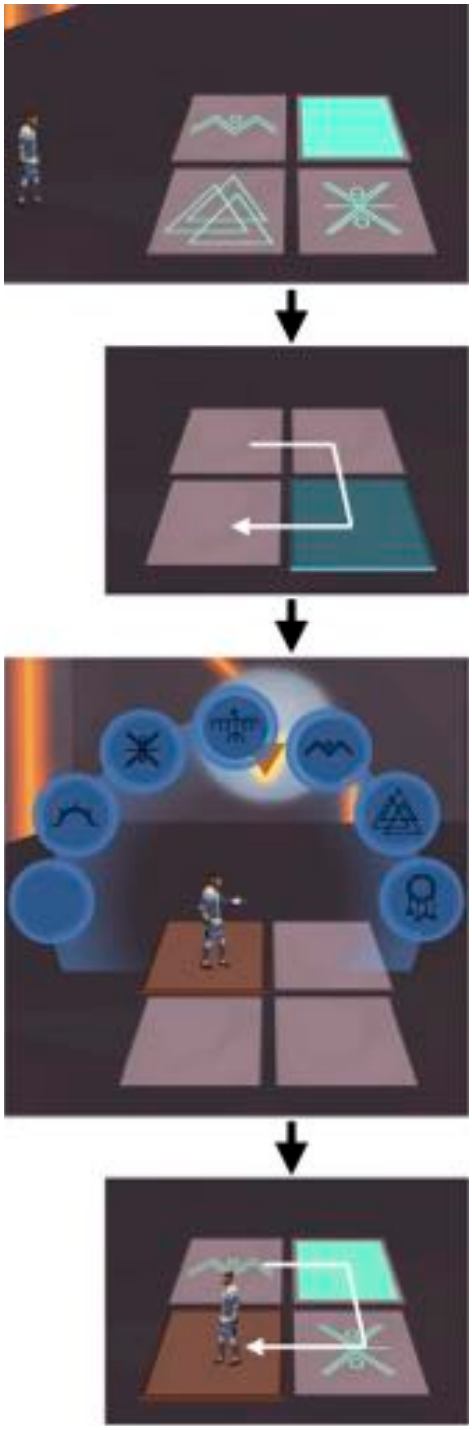

Figure 15. An example of security lock. Firstly, Kiva shows the symbols and the path of answer; then, Hoa'manu must replicate it.

3.5.5. Kiva - the energy panel

Once Hoa'manu reaches the top floor of a Kiva, it can access the energy panel. The objective is to solve a series of puzzles in order to redirect the energy flow, expose the core of the tower, steal it and deactivate the structure. The energy panel is divided into three sections (Figure 16). The main section represents the *canvas* of the puzzle. The canvas is a two dimensional surface that shows the elements of the puzzles. The basic elements are the entry point of the energy flow and the exit point. A glowing ball represents the energy flow.

The goal of the player is to modify the canvas in a way that the glowing ball, starting from the entry point, will reach the exit point. To modify the canvas the player must use the objects available in a second sub-panel representing the *toolbox*. The toolbox contains a set of objects that can be dragged and dropped in the canvas. The last section of the panel contains the *control* button of the panel, which is used to play or stop the simulation of the puzzle.

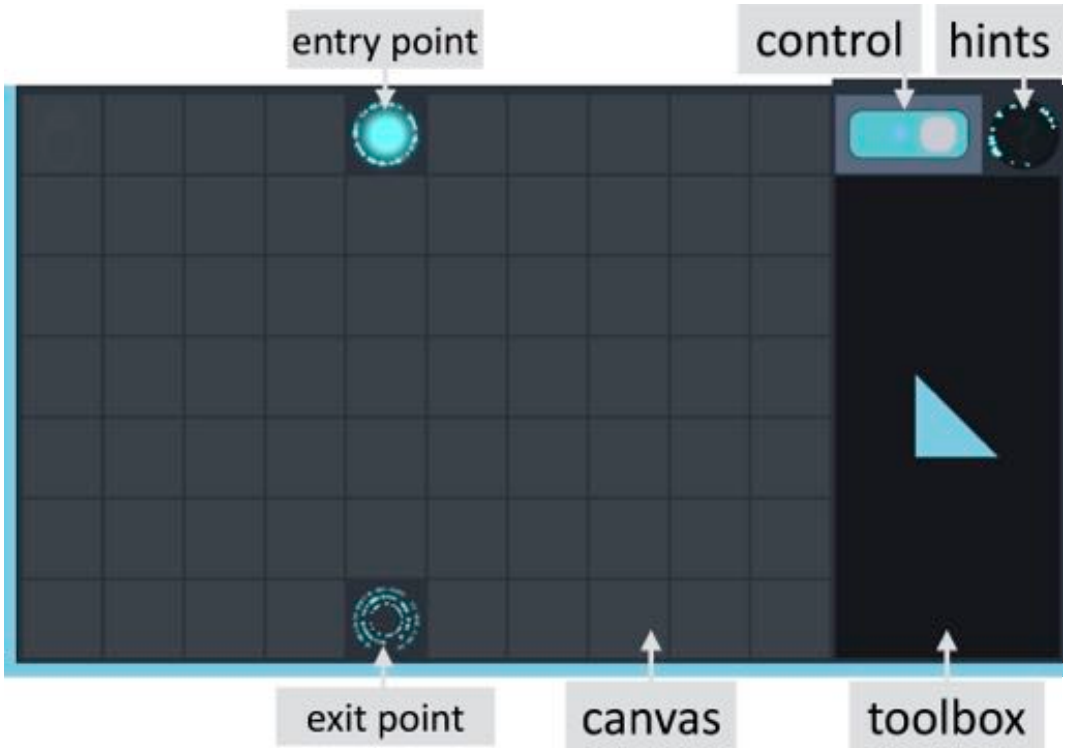

Figure 16. The default layout of the energy panel.

For example, let assume that the entry point is positioned exactly above the exit point (Figure 17). The movement of the ball follows the classic laws of physics. If the player presses the control button, starting the simulation, the glowing ball appears on the position of the entry point and falls directly on the exit point, solving the puzzle.

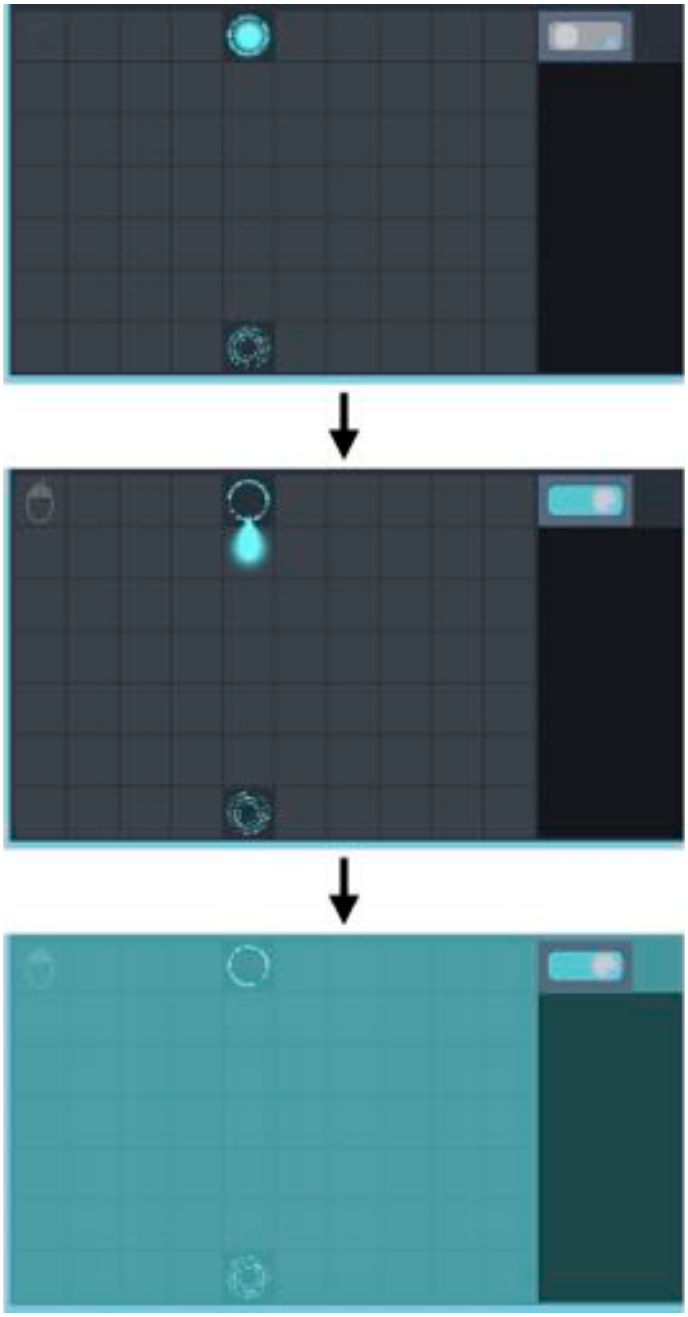

Figure 17. Basic steps of the first puzzle of the energy panel.

In another puzzle the exit point is below the entry point, but placed on one side (Figure 18). Starting the simulation, the ball falls and bounces on the floor of the canvas; in the end it stops without reaching the exit point. The player stops the simulation and drags a triangle-shaped object from the toolbox to the canvas. She/he places the object below the entry point and restarts the simulation: the ball falls on the triangle and bounces reaching the exit point.

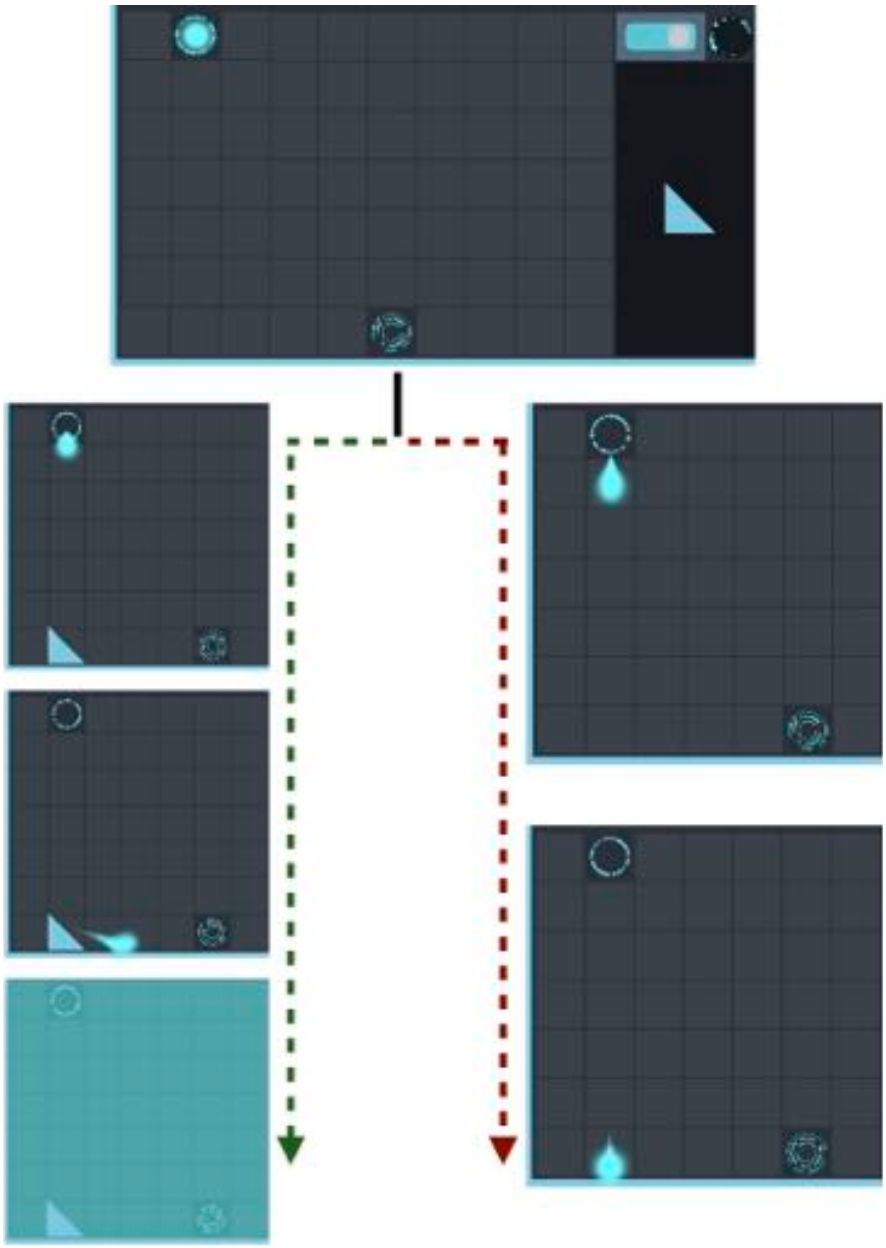

Figure 18. The second puzzle of the energy panel. With no intervention by the player, the energy ball cannot reach the exit point (right part). However, adding a physical object to change the trajectory of the ball, the puzzle is solved (left part).

This mini-game is constituted by a set of puzzles based on gravitational mechanics. In this case, the system does not modify the difficulty according to the player performance. The energy panel proposes a variety of puzzles - four per tower - with increasing difficulty. When the player solves one, the system shows the next. The difficulty of the level is based on various factors. First of all, the puzzles can have default objects in the canvas that cannot be moved. These objects represent obstacles that the player should usually bypass. Moreover, the objects in the canvas and in the toolbox belong to four types:

- physical objects: they modify paths and trajectories of the ball;
- gravitational field: it attracts or repulses any ball;
- laser: it destroys any ball on contact;
- antimatter ball: it has similar shape and behaviour of the energy ball, but if it reaches the exit point the player fails the puzzle.

If the player cannot solve a puzzle she/he can use some hints, which will provide a visual clue of the solution. Every puzzle has a maximum of three hints, from a vague clue to the representation of the entire solution, that can be activated after a fixed waiting time.

The energy panel was inspired by video games like *The Incredible Machine* series, in which objects are placed in the game world to create Rube Goldberg's machines. The mini-game was designed to train planning skills: the player has to carefully understand the cause-effect relationships of the various objects and plan their disposition accordingly.

3.5.6. The call

Every time Hoa'manu deactivates a Kiva, the Raku must be called in order to reach the village. Hoa'manu does not need to perform the complete ritual because the Raku is flying near the tower. It is sufficient to use a device embedded in the space suit to perform the *call*.

The call is a simplified version of the Rekenanangi (subsection 3.5.1) based on auditory stimuli (Figure 19). First, the device emits a series of sounds. To simplify

the mini-game, there are just three different sounds (a C with low pitch, an F with medium pitch and a B with high pitch) associated with a sub-set of symbols seen in Figure 6. An algorithm decides randomly which sound is emitted next. The length of the combination is based on the difficulty of the game, but maintains a percentage of uncertainty. The persistence of each symbol and the waiting time depends on the difficulty.

After the first part of the summoning, the player must answer by selecting the last *n* symbols of the series. The *n* is determined according to the difficulty and notified to the user - using visual clues - at the beginning of the ritual. The system requires the player to answer correctly three combinations out of five, with the same automatic balance of the difficulty as in the Rekenanangi.

The call was designed to train the working memory based on auditory stimuli. The player has to keep track of the emitted sound and elaborate this information. The process is similar to the Rekenanangi, but the information provided to the player is completely based on sound. In a clinical setting the trainer pronounce a list of letters or numbers of undefined length and the participant has to repeat the last *n* elements of the series.

Figure 19. The environment where the call takes place. The process is similar to the Rekenanangi, but based on auditory stimuli.

3.5.7. The falling island

While flying from a village to a Kiva, the Raku may spot an island collapsing and some villagers in danger. Hoa'manu must descend on the island and rescue the villagers. However, some sentinels have invaded the island. The main character can shoot them, but due to the low amount of energy of the plasma gun and the incredible speed of the sentinels every bullet must be used wisely. The Raku, following from the sky, can spot the enemies and help the main character.

In this mini-game Hoa'manu is continuously sliding down the island (Figure 20). The player can only interact using the fire button. The enemies are too fast for the human eye and shooting at sight is not effective because the sentinels have enough time to fire at the player before being destroyed. The player cannot repeatedly fire blindly because the plasma gun has a delay time from one bullet to the next. The only way to win the mini-game is to listen to the two different roars of the Raku. The roars have an identical first part, and differ in the second part. When a roar ends with a high pitch the player should shoot, as a normal sentinel is approaching. When a roar ends with a low pitch the player should not shoot, as a shielded sentinel is approaching and any bullet would ricochet. In general, the low pitch roars are less frequent and so are the shielded sentinels. This factor determines the real difficulty of the game. The repetition of the same roar - the high pitch one - induces a response expectation in the player; however, to win the game she/he must be attentive and inhibit the response (i.e., not pressing the fire button) in the case of low pitch roar.

Every time Hoa'manu is hit, it loses some health points. If the health points reach the zero, the scene is restarted form the last checkpoint. As consequence, the player will receive a smaller final prize. The number of sentinels, the maximum time available to press the button, the number of checkpoints and the total duration of a session are determined by the level of difficulty. The difficulty is updated based on the health points lost by the player. The mini-game is completed when Hoa'Manu reaches and saves the villagers.

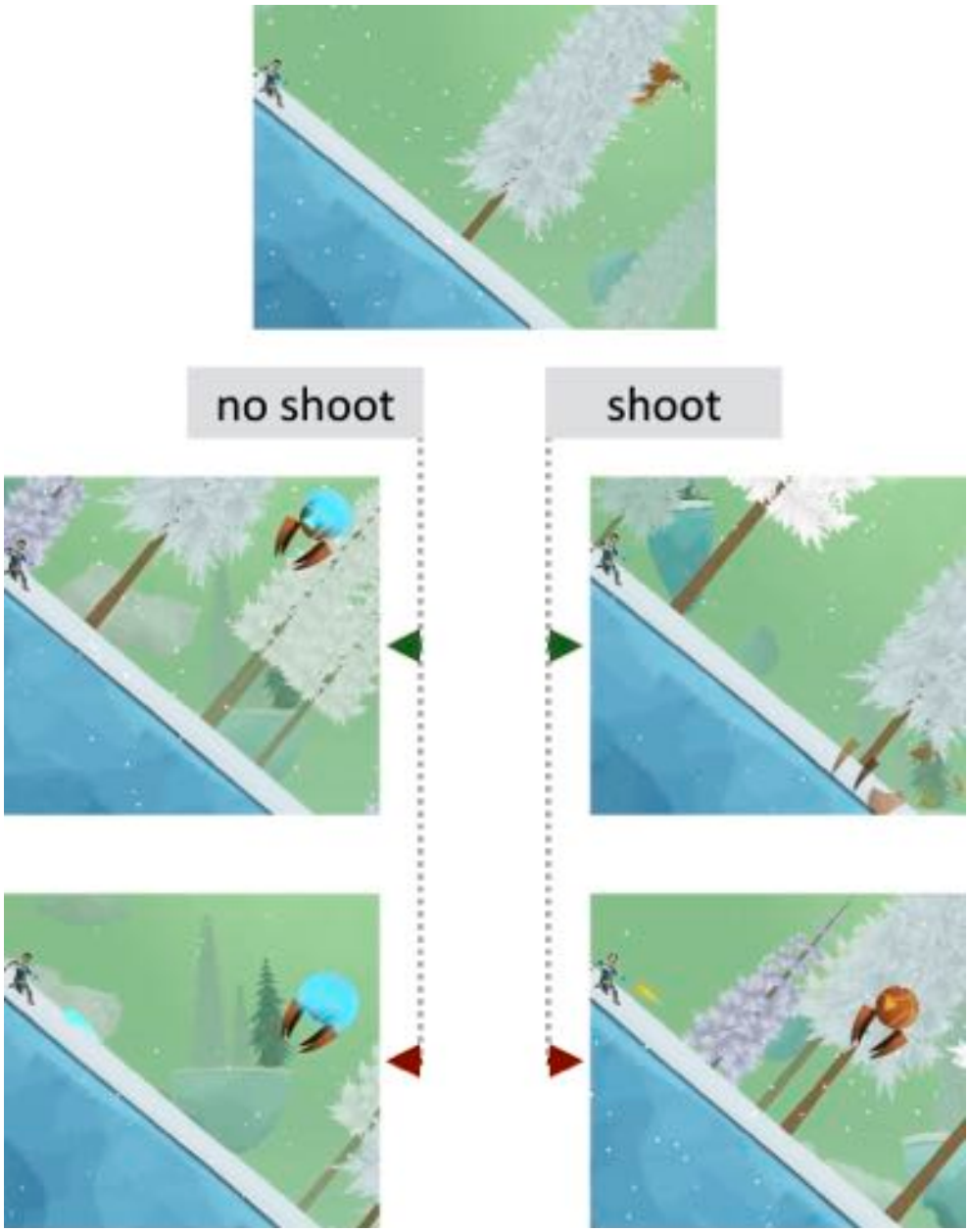

Figure 20. Examples of possible reactions by the player: the upper part shows the right answer for the shielded (left) and shooting (right) sentinels; the lower part shows the wrong ones.

The falling island was designed to train the response inhibition based on auditory stimuli. The player must follow the sequence of sounds and react accordingly: she/he has to quickly react on the high pitch roars, but she/he should also be able to inhibit the motor response by listening carefully to the various roars and not reacting to the low pitch ones. In a clinical setting the exercise is quite similar and will be described in subsection 4.1.

3.5.8. Meteors and islands

While flying from one village to a Kiva, the Raku may spot one of the keys that are required to open the Kivas. The keys are stored in small temples that are located in big clusters of meteors and small islands. Hoa'manu has to descend on the islands and reach the temple, while the Raku has to follow the character flying through the meteors.

In this mini-game the player has to control both Hoa'manu and the Raku (Figure 21). The former runs automatically moving from one island to the next; the player has to use the jump button to avoid any fall. In parallel she/he has to move the Raku in order to dodge the meteors. To clearly divide these tasks, the character and islands are placed in the foreground, while the Raku and meteors are in the background of the scene.

Every time Hoa'manu or the Raku are hit, they lose some health points. If the health points reach the zero, the scene is restarted from the last checkpoint. The difficulty is updated based on the total loss of health points, and it determines the

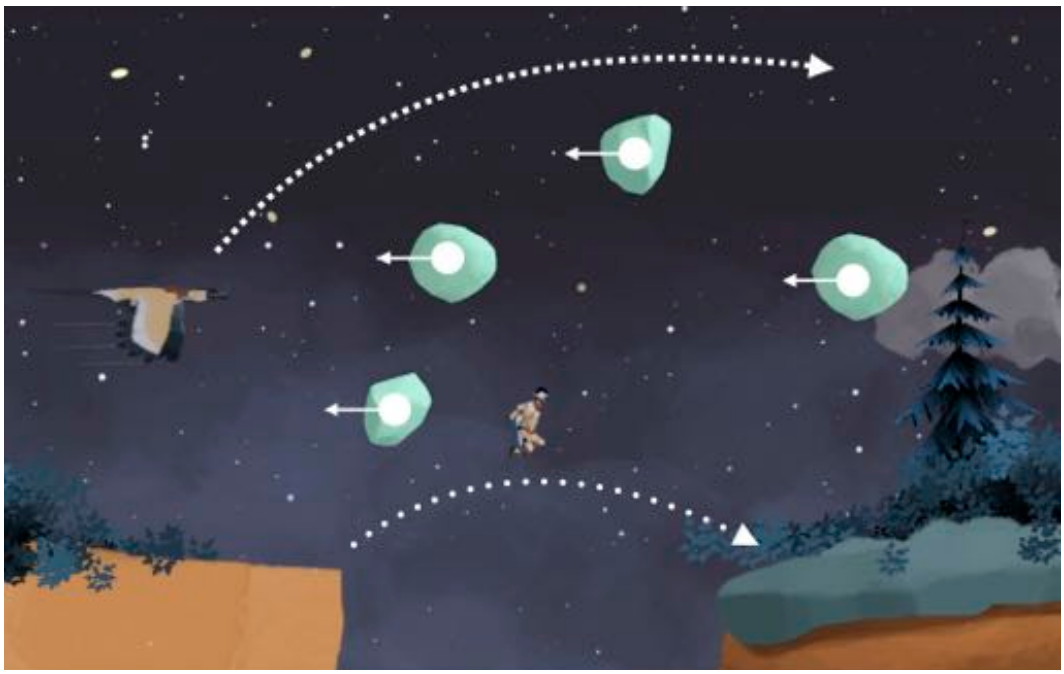

Figure 21. The player has to control the jump of Hoa'manu, while moving the Raku to dodge the meteors.

speed of Hoa'manu and the Raku, the number of checkpoints, the density of meteors, the distance between the islands and the total duration of the session. The mini-game is completed when Hoa'manu reaches the small temple and retrieves the key.

The mini-game was designed to train the split attention. The player must be able to rapidly switch the focus between Hoa'manu and the Raku, avoiding falling from the islands while dodging the meteors. The simultaneous control of the two characters forces the player to split the attention in order to succeed.

3.5.9. Secret island - the shell game

After the first couple of missions a mysterious villager will appear in the forest's village (first village of the game). The villager is one of the *agents* living in the secret island, located in a region of the world known by only few people. The agent can teleport the main character to the secret island whenever the player wishes to do so. On the secret island two other villagers propose two different mini-games. The player can interact with them and play in order to gain additional resources that can be spent for upgrades.

The first mini-game is a shell game with similar mechanics to the fishing of subsection 3.5.3. The villager shows a set of cards (Figure 22), from three to six, each showing a symbol (Figure 6). One in particular shows the eagle, which is the symbol of the fogs' village. Then, the villager covers the cards and shuffles them. Finally, the player must identify the position of the eagle.

The number of cards and speed of shuffle are proportional to the level of difficulty. The number of iterations is always set to five. The difficulty is determined by the performance in previous sessions with similar rules to the fishing. As well the shell game was designed to train the visual selective attention.

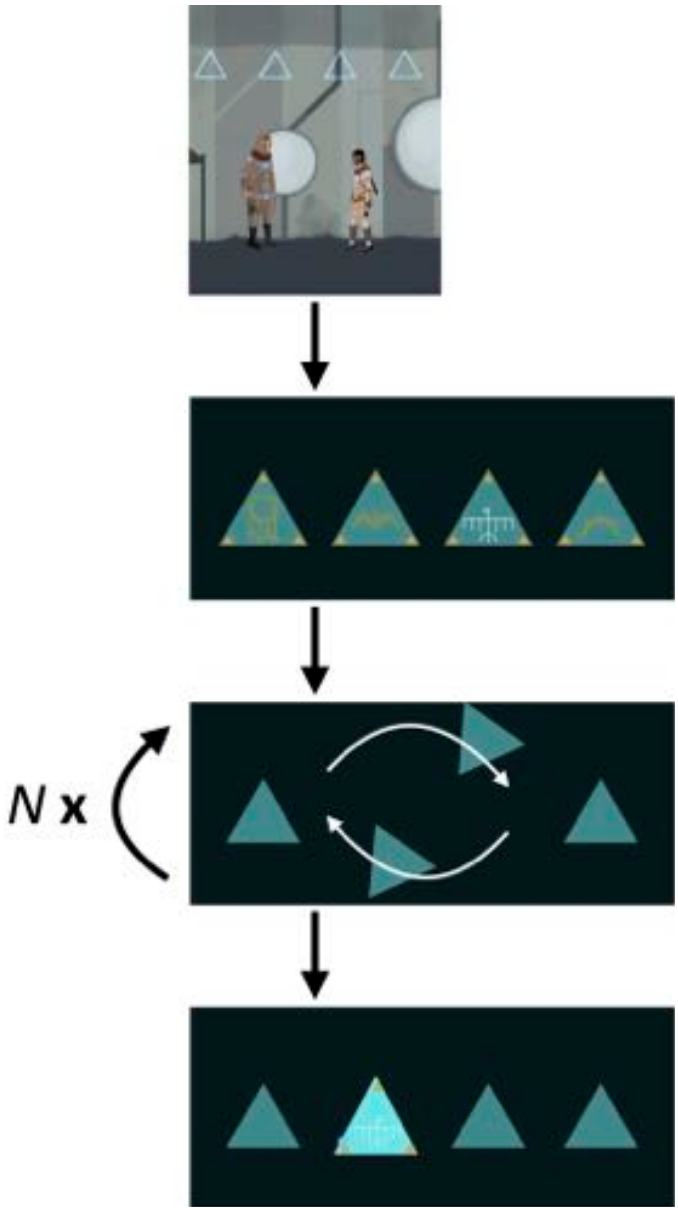

Figure 22. A shell game session: the cards are revealed and shuffled; finally, the player has to identify the correct one.

3.5.10. Secret island - the shooting gallery

The second mini-game has similar mechanics to the shooting galleries of amusement parks (or Whac-A-Mole arcades). The screen shows a simple representation of a little theatre (Figure 23). During the mini-game, some fake sentinels pass through the little theatre. The player has to anticipate their movements and use the mouse to point and shoot them; for every hit she/he gains one point.

The total number of sentinels, their speed and the duration of the session are proportional to the level of difficulty, which is adjusted according to the user performance (the percentage of hit sentinels) during the previous session. Similarly to the flight sessions, the shooting gallery was designed to train the visual sustained and the selective attention. In fact, the player must pay attention to the entire screen, being careful to discriminate targets coming from various unpredictable areas of the screen from the other objects in the scene.

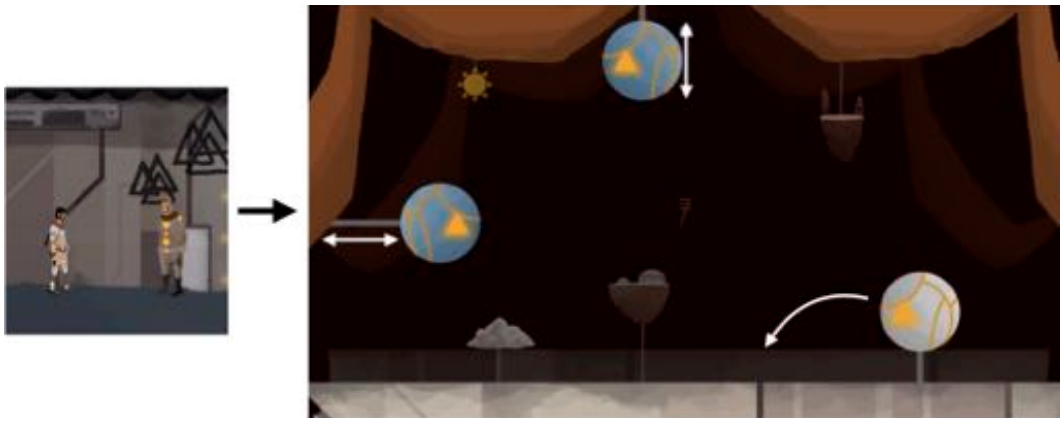

Figure 23. In the shooting gallery the fake sentinels move around the screen. The player has to click (shoot) on them in order to gain points.

4. GAME DESIGN

The development of Skies of Manawak was structured over almost two years. In this period, the project was divided into several stages (Figure 24). Due to the amount of information, and for a stylistic reason, the description of the design process is divided into two chapters. Chapter 4 describes the stages from the conceptual idea to the alpha version of the game. Chapter 5 focuses on the evaluations that were run starting from this last version.

This division is obviously a simplification and the two parts shared some common activities. The project followed an iterative process, where each stage produced information that was used for the advancement of the design, but also to review previously defined elements. The combination of design, implementation and evaluation composed a well-structured iterative process in the overall development of the game. What particularly characterised the project was a strong involvement of the various stakeholders, namely the domain experts (i.e., cognitive scientists) and the players (i.e., children between 8 and 13 years old). Both took part in various phases, as shown in Figure 24, eventually becoming co-designers of the product. In particular, one of the domain experts was incorporated in the development group almost from the beginning. She provided consultancy on cognitive training throughout the project finally becoming one of the game designer. She was involved at all stages including both the activities in which her contribution had a direct consequence on the design, but also when the involvement was more oriented to the players, in which she participated in the research work (e.g., organization and observation of workshops).

The players were involved in the design process, not only as evaluators of the product, but also as creators. They greatly contributed to the definition of the basic elements of the game, developing the first concepts, and providing feedback during the overall development. Unlike the domain experts, their contributions concentrated on specific stages: even if their judgment had a strong impact on the product, they did not entirely played the role of designers, but rather what Scaife and Rogers (Scaife and Rogers, 1999) would define as informants.

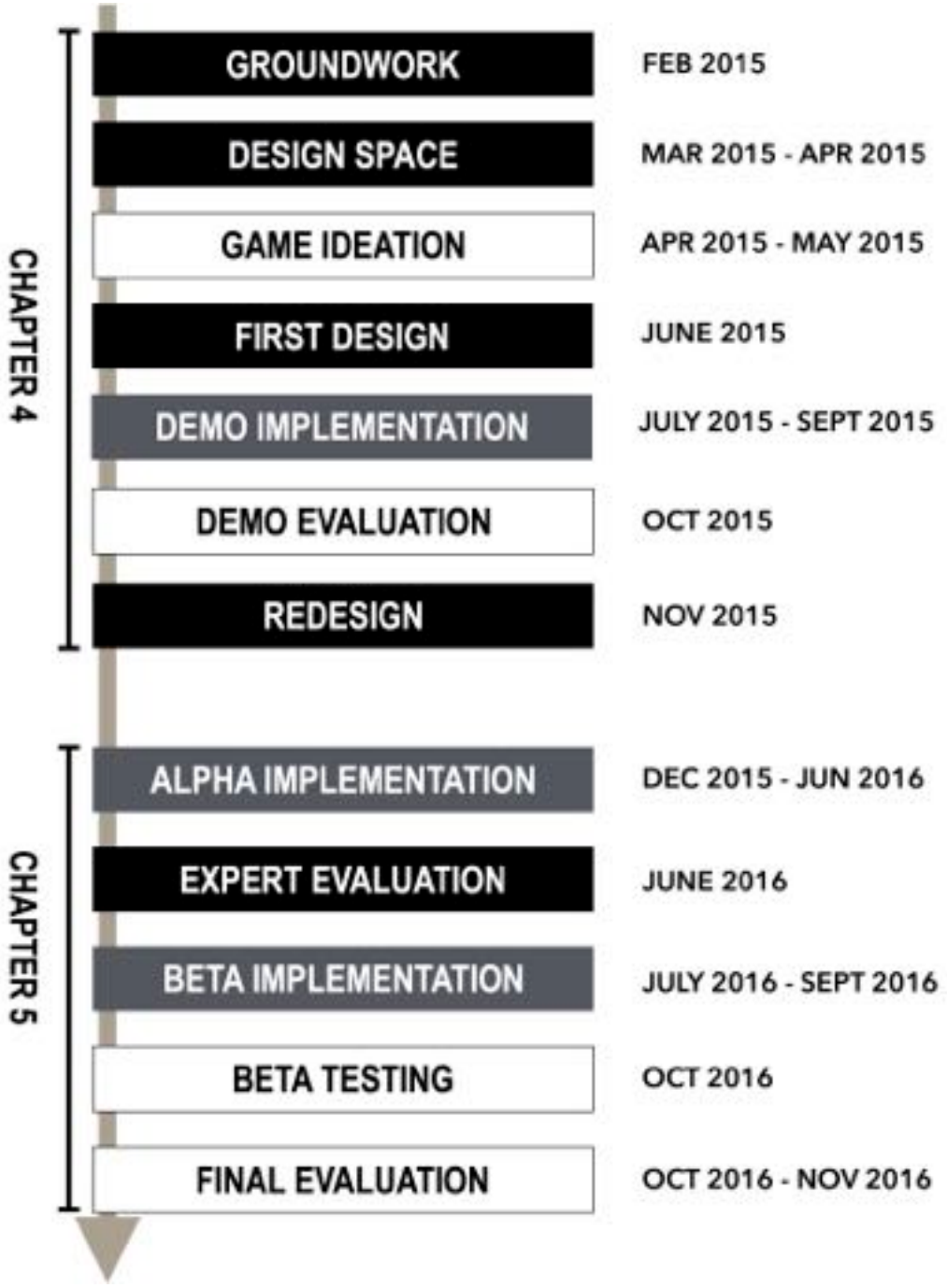

Figure 24. Main stages of the design process of Skies of Manawak.

During the process the designers applied various techniques and tools to structure a participatory game design process. The methods were partially inspired by other similar works on similar domains (IJsselsteijn et al., 2008; Khaled and Vasalou, 2014; Moser et al., 2012, 2014a), which were adapted according to the different activities and the design space. Other new methods and tools were introduced to facilitate the knowledge transfer and the definition of a shared design space between stakeholders, and to more effectively involve players.

A comprehensive description of the stages of the design process, presenting the involvement and contribution of the various stakeholders and the methods and tools applied, are described in the next sections. In order to highlight the most important considerations, the text is enriched by a set of visual clues. These clues are represented as symbols, placed at the beginning of the sentence or paragraph describing a specific argument. Symbols and arguments are arranged as follow:

- Methodological reflections
    - (■) on relevant design techniques and tools;
    - (◆) on practical issues related to the design process;
- Game design reflections
    - (✚) on story, aesthetics, mechanics and technology.

This simple system of visual clues is aimed at supporting the reader in identifying the most important considerations and findings of the design process and to relate this information to the content of chapter 3 and what will be presented in the next sections.

The documentation of the design process of this game for purpose, enriched by theoretical and practical reflections and connections with previous research, represents a new contribution to the research on the subject. The author firmly believes that in order to expand the research on games for purpose, the reporting of this kind of experience is crucial. From a theoretical point of view, it stimulates a deeper discussion on the value of these video games (Marsh, 2011); from a methodological point of view, it supports other researchers in planning and managing these rather complex design processes (Moser et al., 2014b).

4.1. Groundwork

The first stage of the project can be summarized in a series of introductory meetings spread over one month and aimed at initiating a transfer of knowledge between designers and domain experts and identifying the competences of the participants (Vasalou and Khaled, 2013). The initial group was composed of around ten people including clinical psychologists, cognitive and computer scientists and a visual artist.

These preliminary meetings were divided in two phases. ■ Firstly, the cognitive scientists organized two presentations with an educational purpose. The first meeting focused on dyslexia and provided a basic background about learning disabilities. The second meeting focused on the training path applied at the clinic of ODFLab; the experts described a series of exercises, explaining the connection between a specific exercise and the associated EFs.

For example, the cognitive scientists described the exercise of the *small frogs* used for the treatment of children with learning disabilities. The user receives a sheet depicting twenty columns, each divided in fourteen cells. A small frog is drawn in each cell, to give the idea that the frog needs to jump from one cell to another. The user has to carefully listen to a recording that presents two different types of sounds. A *go tone* means that the user has to mark the next cell of the column, and a *no-go tone*, different from the first, means that the user should not check the next cell but instead move to the first cell of the next column and wait for the next tone. The exercise is aimed at training the response inhibition. To be successful the user must be able to follow the rhythm of the sequence of sounds, and simultaneously inhibit the motor response, being able to stop in time on the no-go tone after hearing a variable number of go tones.

■ The subsequent meetings were organized by the designers and had an informal probing approach. The designers showed a set of games and mini-games (e.g. the banjo duel in *The Curse of Monkey Island*) that were considered cognitively challenging, inviting the cognitive scientists to play with them and experiment with prototyping tools. The game designers showed a series of videos of game

sessions, whose selection was based on mechanics that the designers hypothesized could be related to the mechanics of the exercises used by the experts. For example, they showed a video game with similar mechanics to the *shell game* described in subsection 3.5.3. Each video game proposed by the game designers was deeply analysed by the experts, discussing the game mechanics in relation to the training of specific EFs. In the case of the shell game, the experts pointed a clear link to visual selective attention.

The grounding stage was especially relevant in the design process. Not only did it support a mutual learning between cognitive scientists and designers in terms of knowledge but it also allowed them to experience different working practices and cultures. The meetings supported the creation of a common knowledge base, which allowed the participants to take joint decisions on the of design, avoiding setting clear boundaries between competences and responsibilities.

At the end of this stage all the parties agreed on the design goals and the activity plan. The interdisciplinary development team (N = 4) was composed of two PhD students in computer science working on video games[2], a visual artist, and a PhD student in cognitive science. A steering committee composed of senior researchers in HCI and Clinical Psychology supervised the project since the early stage.

4.2. Design space

Following the preliminary meetings, the team envisioned a high-level game scenario integrating into the story a set of mini-games that would have addressed the cognitive training requirements. The basic idea was that the player followed a story that at times required the engagement with mini-games integrated in the story. This structure would have allowed having full control over the stimulation induced by the mini-games, to ensure compliance with clinical requirements while providing an engaging experience. However, it was immediately clear that the quality of the integration between the main game and the mini-games was crucial.

[2] One of the two students could only participate in the first part of the design process. The other, author of this thesis, followed the whole process as lead designer and programmer.

At this stage, the focus of the design was on a seamless transition between gaming and training in terms of story and aesthetics.

4.2.1. Game concepts

✚ The development team agreed that elements such as story and aesthetics would have been decided with the players. However before discussing any possible design proposal with them, it was necessary to narrow down the design space. Discussing the implications of the design of the video game on the cognitive training, designers and domain experts agreed that not all the possible game genres were suitable for the purpose of the video game (Laporte et al., 2013). This fact can be better explained through an example. Let us conceive the cognitive exercises as puzzles. If the players would choose a game concept based on racing, the integration of puzzles in the design could be quite difficult. Considering the game mechanics (e.g., steer, speed up, break) and the story (e.g., participate in and win a racing tournament), the puzzles would be perceived as disruptive elements. Following the MDA framework (Hunicke et al., 2004), they could break the rhythm compromising the dynamics. In addition, they could be perceived as out of context, compromising the story (Schell, 2014). The same could apply with other genre, like first-person shooters or fighting games.

■ The team focused on the possible types of game that would have been suitable for the purpose. In order to do so the designers proposed different video game concepts in order to assess the implications of the game type on the training. For example, one of the scenarios was a sort of Olympic Games, organized by fictitious animals of the forest. Several design workshops were run to outline a number of game concepts that could suit the training purpose. The aim of these workshops was not to identify a specific solution, but to sketch the design space in terms of the gaming components that could better fit it. The proposed game concepts supported the definition of the design space by outlining which kind of games could give enough freedom to integrate different exercises.

4.2.2. Mini-games selection

■ In parallel to the game concepts, the team focused on the selection of mini-games. This activity helped to refine the design space in terms of the training component following a three-phase structure. Firstly, the cognitive scientist selected a series of exercises used in the clinic for the training of the EFs (e.g. attention, working memory and planning). Secondly, the exercises were deconstructed into their structural components, translated into game mechanics and reassembled as mini-games. This activity provided a robust theoretical framework to ensure the clinical compliance of the game.

The team discussed implications of such mini-games on the design. ✚ For example, while analysing several exercises targeted to the training of the working memory based on auditory stimuli, the team discarded most of the proposals because they would have strongly constrained the story. In fact, this kind of exercise is usually based on a procedure in which the exercise presents a set of words (e.g., key, desk, oven, value, trunk, battery) and the subject has to reply following a specific elaboration (e.g., the two smallest objects: key and battery). These mechanics impose a strong limitation on the story: who would, in a story, pose a question based on a set of (apparently) random words? Why should the protagonist/s need to answer these questions? This mini-game could be perceived as out of context in many gaming contexts.

Subsection 3.5.1 presented the Rekenanangi, the first design of which started at this stage. The team identified a cognitive exercise on working memory that could be integrated easily into the story. Letters and numbers could be translated into symbols providing interesting directions for game design. By adding the mystery of special symbols, the exercise could be transformed in rituals or hacking attacks, allowing different possible scenarios to unfold. What later became the Rekenanangi, at this stage was only a draft of a possible scenario used to identify possible directions of game design. Raku and Ukas became part of the game design only a few months later.

4.2.3. Poster diaries

During the overall project, the team used various *poster diaries* to document the design process. This design tool was not inspired by previous research, or at least not consciously. It is described here as the author of this manuscript considers that the poster diaries, in their simplicity, are effective tools to support the game design process, particularly in projects where there is more than one designer.

■ The poster diaries, as the name suggests, are large pieces of paper, usually A2 or A1 size. At the start of each meeting the designers write down the main topics of discussion. For example, in this case study a poster could be started by summarizing the EFs already discussed and their related potential mini-games. At this point, designers and cognitive scientists could identify another EF to integrate in the game. Then, some clinical exercises could be noted down in terms of their structural components. Designers and experts could start discussing possible mini-games related to those exercises.

The poster is used to note down the development of the discussion. It does not only serve as documentation for later analysis, but becomes a driving element of the meeting. The large paper size allows the creation of a map: the designers can note down every thought, extend them and define connections and dependencies. The poster serves as visualization of the design acknowledged by the designers. It supports group reasoning and communication in an effort to verify any misunderstanding or misalignment on a particular topic (De Troyer et al., 2013).

4.3. Game ideation workshops

The next stage of the design process was a set of game ideation workshops with children, aimed at defining the game idea and setting the basic game elements desired by the players. This stage was particularly inspired by the ideation workshops developed by Moser and colleagues (Moser et al., 2014a) to create creative low-fidelity prototypes of game ideas that could inspire game designers.

4.3.1. Groundwork

The following meetings focused on the structure of the workshops (Moser et al., 2014a), which can be summarized in three main group activities: the definition of a game idea, the creation of a physical prototype, and the recording of the latter simulating a scene of the video game.

■ The modified version used during this project differentiated by a few elements. The duration was strictly set to two hours and the groups' formation was predefined before the workshop due to the time constraints related to the availability of the participants. The new structure pushed more attention on the ideation section, leaving less time for the other activities but still enough to allow all the groups to develop and video tape a short. Differently from Moser and colleagues, and in line with the constraints highlighted in the definition of the design space, the researchers defined a new design template for the game ideation, consisting of five prompting questions:

- *Who?* the protagonist/s of the story;
- *Where?* the spatial setting of the events;
- *When?* the temporal setting of the events;
- *What?* will the protagonist/s run into someone or something? for example enemies and/or companions;
- *Why?* the motive of the game events.

✚ The template was created to guarantee that the proposal would have fit the design space. For example, proposing the identification of a specific character/s would have automatically filtered any common proposal related to sports, which would have not been suited to the design space of the project. Further, the researchers were more involved in the group work, becoming co-designers and mediators. These modifications were made to focus the workshops on design proposals in order to obtain sufficient material to define the first game design.

4.3.2. Pilot

Before moving to the organization of the workshops, the researchers organised a pilot session (N = 4) in order to evaluate the structure and efficacy. In general, the outcome was positive with a good set of proposals from the players. Still, the children's behaviour was not always in line with the researchers' expectations (Duysburgh and Slegers, 2013; Read et al., 2002). These observations supported the refinement of the structure. ◆ The main modification was on the presentation of the workshop to the players. During the pilot the research group presented the overall structure of the workshop, including the fact that prototyping material would have been provided. Anticipating the overall structure, the group tended to partially lose attention on the first part of the workshop, more interested in moving to the prototyping phase.

◆ Showing the prototyping material resulted in what could be called *fixation*. In the definition of the boss of their game, the children opted for a dragon, because of the appeal of the Lego® miniature, forgetting a fantasy creature they had previously imagined. The fact that children considered the material as a source of inspiration, rather than a simple tool for their imagination, highlighted a critical issue. For the subsequent workshops the prototyping material was carefully selected to represent a source of inspiration (not influence) for the design, choosing unstructured elements that could be used and adapted to needs and would have not biased the participants. Moreover, the introduction to the workshop was reshaped, giving a generic overview of the activities and not mentioning or showing any material related to later phases.

4.3.3. Workshops

In May 2015, the designers organized 12 workshops involving children aged between 8 and 13 years old (N = 60). Each workshop lasted two hours. Children worked in groups comprising three to five children and at least one researcher actively interacting with them. Children were recruited through advertisement at ODFLab and included a class of a local elementary school who visited the University. Thus, the sample involved a mixed group of children with learning

disabilities and children with no specific learning issues (Börjesson et al., 2015). This heterogeneity was important as the focus of this activity was on the gaming component, not on the training purpose of the application.

■ The workshops were hosted in different rooms at DISI and ODFLab. All spaces were set up as children friendly environments (e.g., colourful and comfortable furniture, playful prototyping material) and a snack was provided to make them feel at ease. This setting created a pleasant atmosphere between informal (friendly attitude of researchers), familiar (playful theme) and professional (empowerment of the participants to the role of designers) aspects (Druin, 2002). The children were divided into groups by a therapist who knew them or by their teacher. A summary of the groups' characteristics alongside the location of the workshop is reported in Table 3. The sample exposed a strong gender bias in favour of male children. The team attributed this bias to the advertisement wording, which invited subjects to participate in a video game design workshop. Each child came to the workshop with an informed consent signed by their parents (or guardians). The document provided a clear explanation of the purpose of the workshop, the occurrence of audio and video recording for research purposes, and highlighted the opportunity for the participant to leave at any time.

Table 3. Summary of the participant's information of the game ideation workshops.

date	participants	groups	age	location
6-May-2015	4 (4 M)	1	11	university
11-May-2015	9 (6M, 3 F)	2	8-10	clinic
12-May-2015	24 (11 M, 13 F)	6	9-10	university
13-May-2015	11 (8 M, 3 F)	3	11-13	clinic
18-May-2015	12 (8 M, 4 F)	3	11-13	clinic

■ Every workshop followed the same structure. An *introductory presentation* (10 minutes) opened the session, introducing the members of the development team while establishing an informal atmosphere (Druin, 2002). The researchers described the main goal as letting the participants outline the design of a video game that could be appreciated by their peers. This clear initial message was used to help children understand the importance of their contribution (Iivari et al., 2015). At this stage the designers deliberately omitted any information about cognitive training since the interest was in working with the children on the gaming dimension. Then, the researchers briefly presented the schedule of activities; any detailed description was avoided because of the experience during the pilot.

■ The first phase consisted of the creation of a *design document* (40 minutes), sketching the conception and conceptualization of the game. The researchers asked the subjects to consider three game elements: the character, the obstacles and the final goal. In addition, they were invited to develop their ideas around the prompting questions of the design template described in subsection 4.3.1.

Initially, the children worked individually and outlined their ideas in the form of text and drawings on separate sheets of papers. This individual phase helped the participants to start a more mature collective discussion, avoiding an unequal distribution of power (Van Mechelen et al., 2015). A researcher was involved as a mediator to support consolidation. Each idea was reported on an A2-sized sheet where it was deconstructed following the framing questions (Figure 25 reports the English translation of some ideas). The mediator then turned the sheet and repeated the activity with the whole group, aiming at consolidating a single proposal and resolving any dysfunctional conflict about the idea (Van Mechelen et al., 2015). The mediator did not suggest a specific approach to facilitate consolidation, which followed different strategies entrusted to the participants (Read et al., 2002). In some cases, the new proposal arose from the fusion of several previous ideas or it expanded a particularly interesting one; in other cases, it developed into a new common idea partially inspired by the previous ones.

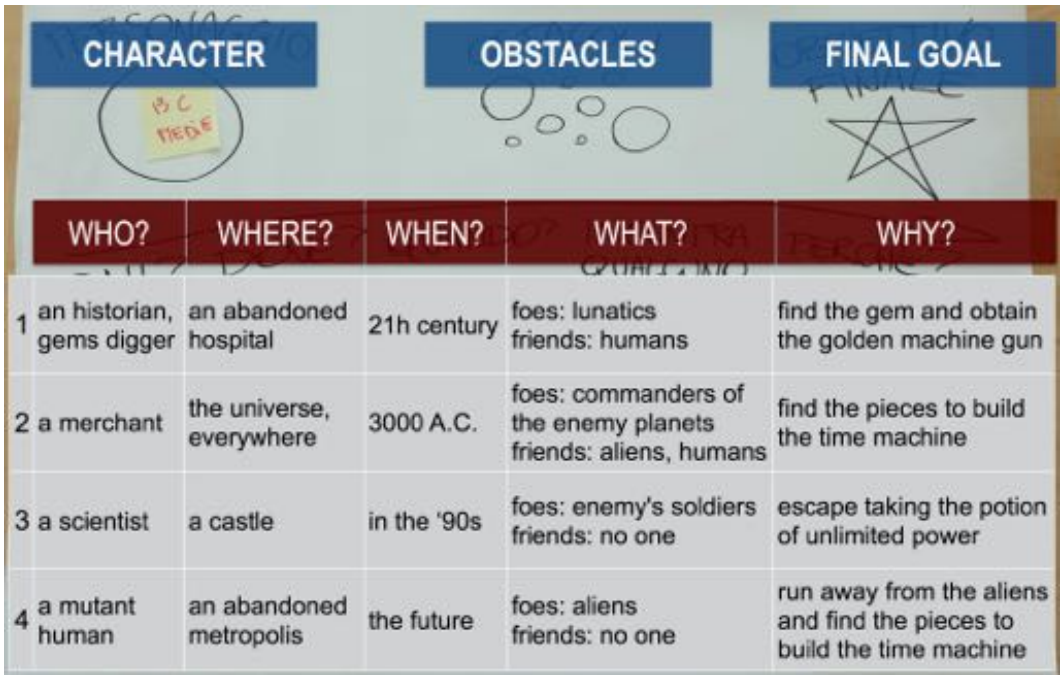

Figure 25. An example of design template filled according to the ideas of one of the groups.

■ The second phase of the workshop was used for *low-fidelity prototyping* (30 minutes). Each group received a set of materials (modelling clay, Lego®, cardboard and PlayMais®) and was invited to create a scene showing their game proposal. The researchers participated in the activity of the various groups. After a short break (10 minutes), they moved to *videotaping* (30 minutes), divided into a preparation phase, where the groups tried their scene, and into the final shoot, where each group simulated a few minutes of gameplay. These two activities, apart from the support given by the researchers and the time constraints, did not have a specific structure. The children were free to chose the prototyping material, as well as how to structure and simulate the game scene.

4.4. First design and demo release

The results of the workshops led to a new stage aimed at creating a draft of the design. The most important information came from the observations of the researchers and the design templates documenting the proposals from the groups. A brief analysis of the videos showed that they did not contain additional information.

■ The data were processed following a thematic analysis. Firstly, the design templates were transcribed in a few spreadsheets. The digitalization was useful to become familiar with the data and identify any patterns in the game elements proposed by the children. Through this first analysis, and following the example of the work by Moser (Moser et al., 2014a), the designers selected a subset of the lenses of Schell (Schell, 2014), which were used as coding variables.

■ The data were clustered on new spreadsheets according to the game elements of the selected lenses, such as competitive and cooperative mechanics (Lenses #36 #37, #38), type of challenge (Lens #31) and reward systems (Lens #40). The clustering helped defining the patterns in the design proposals of the participants and identifying common themes.

✚ A common theme to many proposals was a story that incorporated elements of the *hero's journey*: a hero following a path of personal growth, which will eventually lead to a great victory. The environments had, in most of the cases, a *fantastic component*, and very often they were placed in a time frame positioned in a *distant future*. Another interesting element was the presence of *allies or companions*. Other common game components were *crafting systems, upgrades and rewards*: the hero could build, buy and/or win items, armours and weapons that would help in advancing the adventure.

The following stage was fully devoted to crossing these results with the ones from the game concepts and mini-games, leading to a first design of the game. During the summer the team worked on a demo. The goal was to develop a test version of the game that showed the aesthetics, introduced the story and integrated some exercises. This stage ended with a 30 minutes gameplay containing: an introduction to the mechanics of the game (e.g., controls); three scenarios, with different interactions and slight variations on the aesthetics; the integration of four cognitive exercises, three based on those normally used by the cognitive scientist for the stimulation of the executive system - two of these discussed in subsections 3.5.1, 3.5.4 and a preliminary version of the mini-game of subsection 3.5.5 - and one more experimental - subsection 3.5.2 - on theories about the cognitive

benefits of action videogames (Eichenbaum et al., 2014; Franceschini et al., 2013; Green et al., 2010). The creation of a first interactive artefact was essential not only to evaluate the design, but also to give shape to the idea of the game that could be shared and discussed among the team (De Troyer et al., 2013; Vasalou and Khaled, 2013).

Particular emphasis was devoted to the aesthetics of the game. ■ Since the early stages, the artist kept graphic notes of development. This visual diary not only supported the design through a rapid prototyping of the aesthetics but also helped visualizing the design and consolidating a common idea between the designers. For the sake of simplicity 2D graphics were preferred, resulting in a pleasant aesthetic similar to that of illustrated books.

✚ ◆ The artist intervened directly on the implementation of the game in a continuous dialogue with the programmer. In this regard, some design choices were influenced by aesthetics and programming requirements. Figure 26 shows an example. A possible choice for 2D animation of a character is the use of a sprite sheet, an image consisting of several frames of the animated character. The result, as shown in the upper part of Figure 26 (Menestrina et al., 2014), is similar to Muybridge's *The Horse in Motion*. In the early stage of the development of Skies of Manawak the designers decided to set up the game for a roster of various characters and their customization (e.g., hats and tribal ornaments); the use of sprite sheets would have required the drawing of a sprite sheet for each character, for each animation (e.g., running and jumping) and for each additional element (e.g. running/jumping dressing a hat, running/jumping without a hat). Instead, the visual artist and the programmer decided to break down each character and create a separate sprite for each element of the body (i.e., a sprite for the head, one for the right arm and one for the right forearm); subsequently they animated the different parts through code, with a result similar to shadow puppetry. In this way, each new character required only the creation of the body parts to be applied to a set of standard animations, which could be used independently from the appearance of the character (Figure 26, lower part).

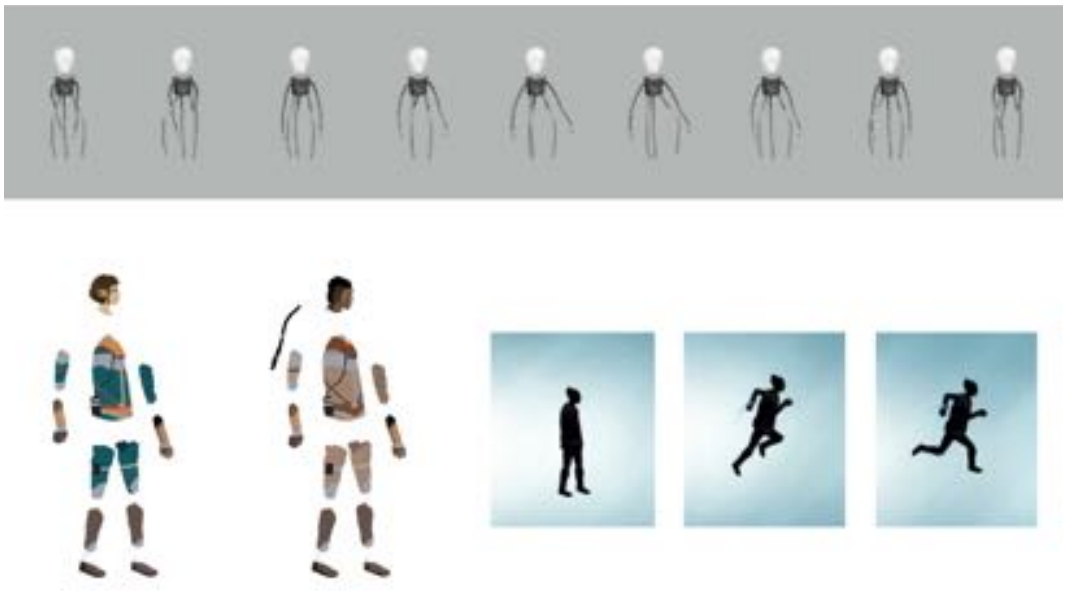

Figure 26. Two examples of animation: in the upper part, a classic sprite sheet; in the lower part, two characters deconstructed in the basic pieces, and a running animation to which the pieces are applied.

4.5. Demo evaluation (formative)

During the development of the demo the designers planned a second involvement of the players for October 2015, in conjunction with a public event organized at regional level for the Dyslexia Awareness Week, widely explored by Menéndez and colleagues (Menéndez Blanco, 2016; Menéndez Blanco et al., 2017; Menéndez Blanco and De Angeli, 2016). This stage of the process had an intermediate purpose: neither focusing on new game ideas - activities now too far behind the development - nor a testing of the software, but verifying whether the current design of the game was appreciated by the players, and collecting feedbacks on possible changes and improvements.

The system was evaluated in two different field settings: school classrooms and a museum. The Dyslexia Awareness Week included a set of activities in five schools across different cities of the region (N = 258). For each school two to four classes were invited to try the first demo of Skies of Manawak and a few introductory exercises of BrainHQ. The aim of this assessment was not limited to assessing the player experience of the game, but to compare it to the tool used for the cognitive training prior to this case study (Pasqualotto and Venuti, 2014).

4.5.1. Groundwork

A few weeks before the event the designers organized a few internal meetings to identify the tools that could be used. The decisions were driven by the goals of the evaluation crossed with potential time constraints and number of participants. Considering an average Italian school, the number of participants per session - based on national average - would have been around 22 children; the sessions could last around 55 minutes, corresponding to the duration of one lesson.

■ In order to evaluate the player experience the designers took inspiration from the extended Short Feedback Questionnaire (eSFQ) created by Moser and colleagues for the rapid assessment of game experiences (Moser et al., 2012). The questionnaire was chosen for two reasons. First the eSFQ was designed for children, as opposed to questionnaires such as the Game Experience Questionnaire (IJsselsteijn et al., 2008) that would have generally been too complex for the target players of this case study. Secondly, the eSFQ is relatively short which was considered to be a positive factor in relation to the short time available for the evaluation and required concentration by the participants (Barendregt et al., 2013; Duysburgh and Slegers, 2013).

The final version of the questionnaire (APPENDIX, Figure 43) differed from the eSFQ in a few elements. The question about how many times the players played the game before was substituted by a question on their will to play it again; being an individual activity, the question about the co-experience was removed. The Likert scales related to the experienced fun/enjoyment were extended using some questions from the Game Experience Questionnaire (IJsselsteijn et al., 2008), with two questions related to flow, two to challenge, two to curiosity, and one to aesthetics. These changes were applied to gather additional information about the player experience.

■ The researchers planned a focus group in classroom as the second part of the evaluation. The aim of this activity was to obtain a deeper understanding of the opinion of the players and, more importantly, to give them the opportunity to express their approval/disapproval about the game and give their suggestions

about modifications and improvements on the design. To facilitate this activity, the designers developed a *feedback poster*[3] divided according to four questions:

- *What did you dislike?*
- *What did you like?*
- *What would you change?*
- *What would you add?*

This template was designed to support the participants to structure their answers and organize their ideas/comments in a way that could be quickly analysed and possibly integrated into the following iteration of the design.

4.5.2. Procedure

■ Each session was distributed across about an hour. During the first half of the evaluation (30-35 minutes), the players tried the two systems. The order of play - first Skies of Manawak then BrainHQ, and vice versa - was alternated from class to class to mitigate any possible bias in the results. Every time the players finished trying one of the two tools, they had to fill the modified version of the eSFQ.

The playing activity was followed by the focus group held in the classroom. The focus group was uniquely intended for the collection of new information for the redesign of Skies of Manawak. The designers presented the feedback poster and asked to the players to provide their opinion on the game according to the four questions of the poster. Each participant had a block of Post-it® notes that could be used to write one or more pieces of feedback related to the questions. For around ten minutes the participants could individually note their comments and stick it to the poster. Finally, the designers moderated a ten-minute discussion about the notes, involving all the class.

Each session had a similar structure, with some variations due to the complexity of the organization of the event. In 45% of the sessions a comparison between the two systems was not possible; in these cases, the activity with BrainHQ was

[3] The designers learned a few months later that the tool resembled the Stanford Feedback Capture Grid ("Feedback Capture Grid," n.d.).

discarded to ensure the correct evaluation of Skies of Manawak. At least two researchers supported by at least one teacher were present at every activity. A summary of the organization of the sessions is shown in Table 4.

Table 4. Summary of the organization of the sessions at the primary schools.

date	participants	classes	age	location
05-Sept-2015	87 (41 M, 46 F)	4	8-11	Rovereto
06-Sept-2015	43 (19 M, 24 F)	2	8-11	Riva del Garda
07-Sept-2015	45 (22 M, 23 F)	2	8-11	Cles
08-Sept-2015	44 (26 M, 18 F)	2	8-11	Levico Terme
09-Sept-2015	39 (19 M, 20 F)	2	8-11	Trento

■ A different type of evaluation was performed during the public event at the museum that closed the Dyslexia Awareness Week. The game was showcased to the public who could freely play with it alongside a number of other demos, critical design artefacts, and scientific information about the theme of dyslexia. For this event four computer workstations, each with a copy of the demo, were available and at least one researcher was present to observe the players and provide support. Due to the large number of visitors, the collected data from these two occasions came only from the observations by the researchers.

4.5.3. Results

The observational data showed a strong engagement with the game. Children were often immersed in playing, not only in the quieter environment of the school classroom, but also in the busy museum: visitors of all ages focused on the game and, despite the environmental noise, almost all of them were absorbed into completing the demo, with several players coming back to play after their turn. The questionnaire data collected in the school supported this general impression.

Regarding the comparative evaluations between Skies of Manawak and BrainHQ (N = 142), the results were generally in favour of the former. The funometer - a

captivating Likert scale from 1 to 5 for the evaluation of fun - recorded a score of 4.57 out of 5 for Skies of Manawak against a 3.85 for BrainHQ. Comparing the two systems, the players generally preferred Skies of Manawak. The answers for the multiple-choice question on the general perception of the game (*How would you define this game?*) are summarized in Figure 27 and Figure 28. Most of the positive elements exceeded those chosen for BrainHQ, and the opposite for negative ones. The elements with a reverse trend were *easy* and *intuitive* for the positive items and *difficult* for the negative, highlighting some difficulties of interaction for Skies of Manawak. Without going in too much detail, the Likerts showed a general preference for Skies of Manawak, where the mean on the various questions was around 4 out of 5 for the video game, and around 3.5 for BrainHQ.

The data gathered during the sessions fully devoted to Skies of Manawak (N = 112) showed a similar trend. As shown in Figure 29, the only negative dimension chosen by a relevant percentage of players was *difficult*: crossing this information with the comments from the focus group it emerged that difficulty was indeed a critical dimension, with some participants considering the game too difficult and others considering it too simple. This dichotomy was attributed to the lack of an automatic balance of the difficulty that could not be implemented in the demo due to the brevity of the game session.

✚ Nevertheless, the game was generally perceived in a very positive way. The focus group discussion demonstrated that the few players who experienced moments of boredom felt it for those parts of the game that were more oriented to the cognitive training. Some participants considered these mini-games too demanding or simply uninspiring. An explanation for this negative judgment came from the observation of the playing behaviour. In fact, some players explored the tutorial without paying attention to the information on the game controls, which were integrated in the game story. As a result, most of them were unable to advance in the game, having to request the intervention of the researchers.

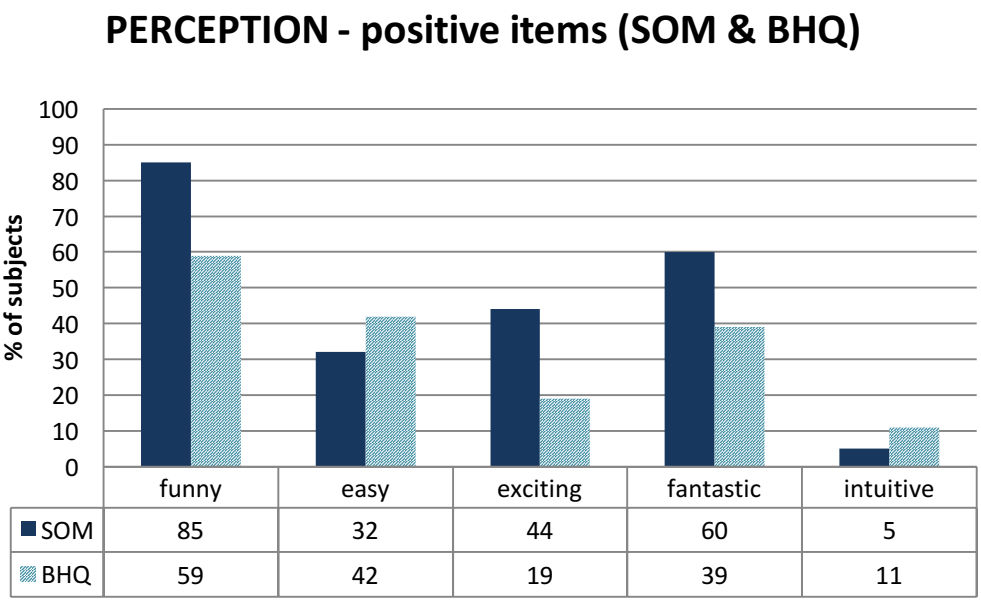

Figure 27. Positive items of the perception questions on Skies of Manawak and BrainHQ.

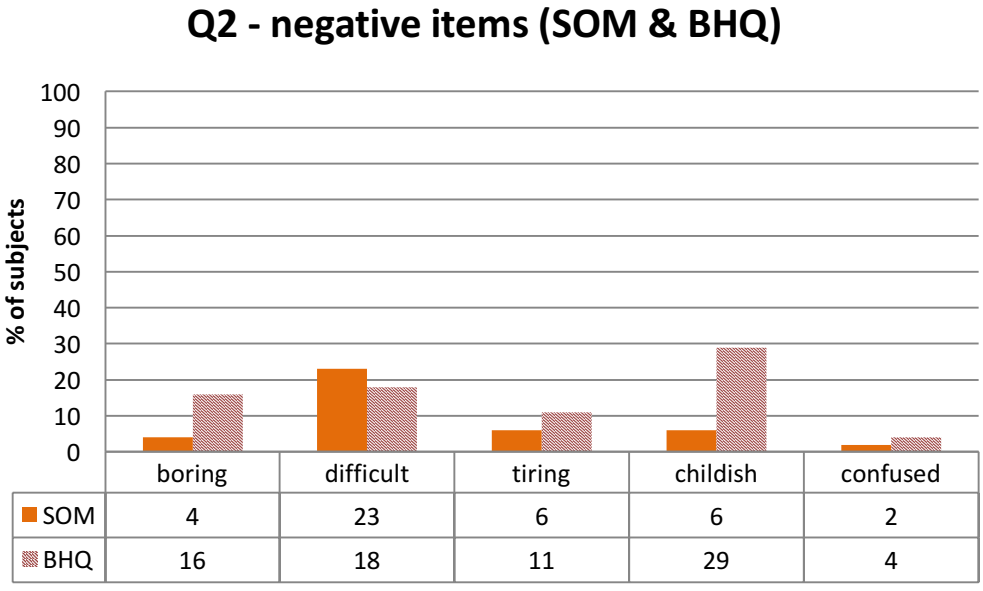

Figure 28. Negative items of the perception questions on Skies of Manawak and BrainHQ.

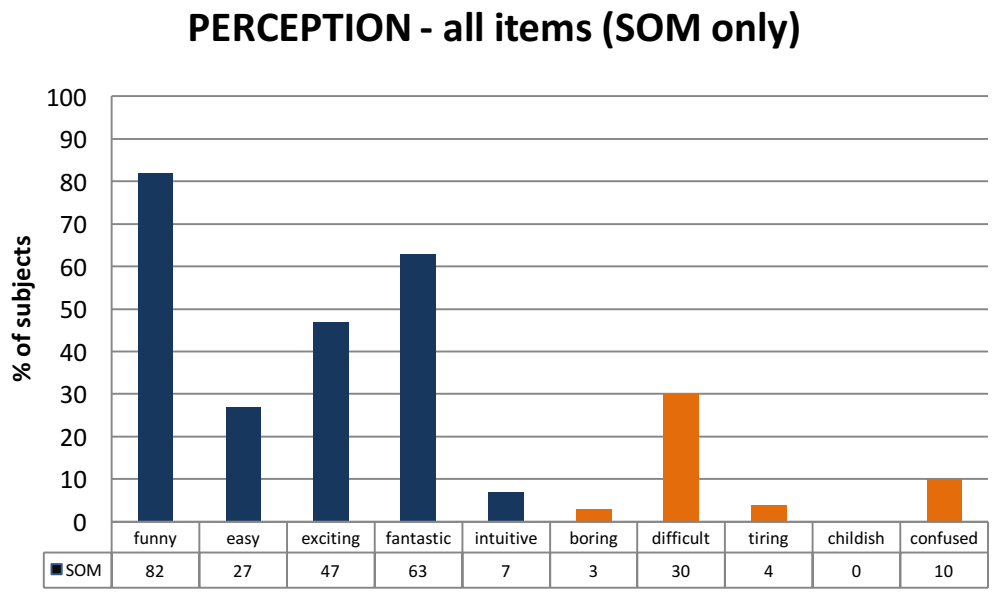

Figure 29. Positive and negative items of the perception question on Skies of Manawak for the evaluations with no comparison with BrainHQ.

✚ This lack of interest in written information, and the constant desire to skip it, are well exemplified in the following field observation collected in the class. A child asked for information about which controls had to be used, although a text indicating the exact control was superimposed on his computer screen. This behaviour, underlined also in other research (Tan et al., 2011), made it very difficult to deal with the parts of game requiring a full understanding the rules. It has to be noted that the demo already supported speech output; however, due to the environmental and technical constraints of the field evaluation, it was impossible to enable any audio support.

✚ Most of the other comments from the focus groups concerned themes similar to those already collected during the game ideation workshops. Many players suggested action elements, such as large quantities of *weapons and enemies* with diverse aesthetics and skills. They also expressed a desire for greater *customization* of the game with a wider range of characters, and for the addition of new features based on *crafting, upgrades and rewards*. These feedbacks provided useful information for the redesign of the game and more details are provided in subsection 4.6.

4.5.4. Problems and reflections

The demo evaluation represented a very important stage in the design process. However, it also highlighted a number of problems between the theoretical planning and practical implementation. The public event required a huge amount of work in terms of communication and coordination of the involved people and institutions. As the event had generally positive results, there were a variety of problems that also affected the evaluation of the game. The organization of an evaluation in a public institution has various prerequisites. It is fundamental to communicate with the people in charge - in this case the teachers and the heads of the various schools - to provide details on the initiative and to coordinate planning. Besides that, considering the use of a video game, as well as other software, it is necessary to collect technical information about the available resources. These may include the computational power of computers, the number of available machines and other services such as a reliable internet connection.

◆ The first problems arose with the first contacts with the institutes. The organization of the event started in spring 2015; since that period the development team knew that some schools were to be involved, but no official list was published. Only two weeks before the event a partial list of schools was defined; until then the designers could not contact teachers and technicians, while the principals mainly communicated with the coordinators of the event.

◆ This delay in establishing a first contact with the institutes imposed additional constraints to the designers. For example, each computer lab had to be set-up with the game installed on every computer before the testing session. The team had to arrange the set-up according to the schools' schedules, while considering that the schools were distributed in different locations of the regional territory (from 2 to 50 kilometres from DISI). In regard to the computer labs, another relevant problem concerned the resources. Each school had computers with different performances and operating systems. The designers had to develop different versions of the game in accordance with these limits. This operation was challenging due to the delays in communication with the lab technicians; an early

communication would have allowed a better distribution of the activities for the preparation of the evaluation.

◆ In some schools the number of machines was inferior to the number of children. The structure of the evaluation was adapted accordingly. In these cases, the designers involved half of a class at a time. This procedure seems trivial, but it had important practical implications. The schools granted a rather low time slot, with an average of two and a half hours to do the evaluations with all the involved classes. To carry out both the game testing and the focus group the two activities had to be organized in parallel: when the first group finished the game session, the second entered in the laboratory, while the first returned to class for the focus group. Obviously, during the first half an hour only one group was involved due to the fact that the latter activity was strictly related to the former. The researchers had to split in order to manage the two activities. To guarantee an effective procedure, all the team members had to be actively involved at all the time.

◆ Finally, the general communication revealed some information gap between the people involved. The main cause was due to the division of communication: designers communicated with the technicians and teachers, but communication between principals and designers was done through the coordinators. In addition to the limits imposed by the technological and temporal resources, and the increased workload caused by the late communication with the institutions, this information gap caused some unexpected events. For example, in a school, the teachers were instructed by the principal to involve two classes every hour, for a total of four classes. Instead, the designers were prepared for the involvement of two classes over two hours. This incongruity implicated a sudden change of the activities similar to the strategy implemented in schools with small laboratories. In one other case, the evaluation was adapted to the practical need of the class to reach the school bus on time (5 minutes before the official end of the lesson).

The problems that arose from the practical limitations of the evaluation were tackled using different strategies. The practical evaluation differed from the theoretical planning, taking to some reflections on the design process. First, the

planning of this kind of evaluation should start by considering the worst-case scenario. In this regard, the researchers should define a basic structure of the activities that could be adapted according to the enactment of the evaluation. This flexibility of planning should fit the worst-case scenario.

■ ◆ The planning of the basic structure of activities should start from the available resources. The designers should consider the time: the scheduling of the activities, the availability of the people involved, and more practical timing such as moving 20 children from one room to another. Another type of resource is the physical space: the available rooms and furniture, such as the number of chairs but also the existence of a blackboard. Finally, considering the use of software, the technology should be considered: the performance of the computer, the support of audio and video (if audio is needed, are the users supposed to have headphones?), and the installation requirements.

■ ◆ Another aspect that the designers should consider is uncertainty. This can be caused by a lack of communication, but also from uncontrollable external factors. Even considering the worst-case scenario, the designers could face unexpected variations to the plan and should be able to react accordingly. In this case study the designers embraced this fact and managed the evaluation activities always contemplating that "every day is a new different day". In these terms, the designers applied a basic structure to the evaluation's activities, adapting them according to the various situations. Repeating the exact same procedure for all schools would have probably invalidated a good percentage of evaluations.

4.6. Redesign and alpha release

After the evaluation, the researchers analysed the observations, questionnaires and posters used in the focus group, which constituted an essential resource for a new iteration of the design. ■ The data from the posters were clustered using a similar process to that described in subsection 4.4. The designers digitally transcribed all the Post-it® notes and grouped them according to the four questions. Then, using a selection of lenses of game design (Schell, 2014) as a reference coding, the notes

were further regrouped. The coded information from the posters was integrated with the observations and used to identify specific themes for redesign.

✚ The data partially confirmed the design choices and helped to focus attention on specific game elements that were not considered entirely satisfying. The *redesign of the controls* and a strong *simplification of the tutorials* were given priority. Similarly, attention was given to increase the reliability of game balancing algorithms in order to *personalise the difficulty* of the mini-games to the individual and highly heterogeneous skills. Further, the *upgrade system* - until then only sketched in the design document and completely absent in the demo - was discussed within the team and included as a basic component of the game. The request for a larger *roster of enemies* (and the addition of boss enemies) led to the implementation of new sentinels and the phoenix, described in section 3.5.2.

■ ✚ However, not all suggestions were directly implemented in the design as some needed mitigation not only based on the design context, but also on designers' values. One example related to the request of many players of the possibility to choose between more masculine and feminine characters, stereotyped according to the idea of the "muscular hero" and the "princess". This proposal was discarded as it clashed with the gender stereotyping concern. Similarly, other requests concerning violent content were strongly moderated according to the general values of the designers. For example, the mini-game described in subsection 3.5.2 is based on aerial battles, yet all the enemies are non-organic entities, reducing the violent act of killing to the dismantlement of lifeless objects. The redesign afforded the opportunity to adjust the choices made up to that moment and to extend the design document. Starting from December 2015, the team worked on the new implementation, incorporating the changes that arose during this first evaluation stage.

4.7. Conclusion

The various stages that formed this first part of the design process contributed to the overall development of the game, resulting in theoretical and practical reflections. The groundwork was a necessary step. As shown by other projects,

this first phase aimed at setting the bases of the project and allowed to anticipate a number of organizational problems (Vasalou and Khaled, 2013). First, the transfer of knowledge within the team created peer communication, where each individual enriched the dialogue with their own expertise, not isolated in their own roles. This common dialogue was essential to jointly define the objectives of the project, thus avoiding misalignments or misunderstandings (De Troyer et al., 2013).

The next stage was useful in roughly defining the design space. Although this was later set more in detail with the players, this stage was relevant in establishing a strong relationship between the designers and the domain expert, and later between the team and players. For the former, the proposed game scenarios and the selection of mini-games clarified the game genres that had the potential to provide a playful and effective experience for the particular context (Laporte et al., 2013). These considerations enabled the team to identify the viable solutions that would have satisfied the project's objectives while leaving enough room to work with the players for new playful solutions (Hall et al., 2013).

The game ideation workshops benefited from this adjustment of the design space. The dialogue with players was more structured, where the individual design phase and design templates ensured that children remained motivated and stimulated to develop more structured reasoning. As for other participatory game design studies, the involvement of children proved to be complex (Moser et al., 2013). In this regard, even if the stage strongly relied on an already tested method (Moser et al., 2014a), the pilot was a necessary step, which demonstrated how the practice deviated from the theory. The introduction of new design tools for this (e.g., design templates, subsection 4.3.1) and later stages (e.g., feedback posters, subsection 4.5.1) proved to be essential to keep children focused, whose attention and commitment were very variable (Scaife and Rogers, 1999). Game design research proved to be a particularly useful resource, both for refining the workshops and for data processing, where for example the lenses (Schell, 2014) supported the thematic analysis.

The ideas gathered from the players proved to be essential for the development of the game. The children, with the right support from the designers, provided relevant information about their needs and desires, which defined the first real design of Skies of Manawak. This stage also highlighted the influence of practical factors in the design process. For example, as described in section 4.4, the skills and resources of the programmer and the artist imposed limitations over the project, where the development of a 3D video game would have been impossible. Although this particular aspect is not often addressed in the literature (Vasalou and Khaled, 2013), in the case study proved to be another fundamental factor of the design process.

The evaluation stage was organized to verify the appreciation of the first version of the game and to identify new ideas for the refinement and extension of the design. This stage underlined once again the importance of the involvement of players, who provided new useful information for the redesign, thanks both to the observations and to their direct intervention through the focus groups (Read et al., 2002). Still, the young age of the target group imposed some limitations. For example, a more detailed questionnaire could have provided richer data on the player experience; however, considering the first experience with players and previous research studies (Moser et al., 2012), an in-depth assessment would probably have been affected by a negative emotional response from the participants. In a more practical view, the activities were very challenging. Even more than for previous stages, the real case deviated from theory; even if the team tackled the various unforeseen events, these clearly showed the complexity of the process. For this reason, the stage confirmed the importance of the documentation and dissemination of these experiences (Khaled et al., 2014), not only oriented to the efficacy of the game, but also to a more structured discussion on the game design process.

In general, this first part of the design process gave confirmations but also highlighted shortcomings with respect to the research on the subject. As already stated in various participatory game design studies (Dodero et al., 2014; Melia

and Di Loreto, 2014; Tan et al., 2011), stakeholders' engagement is critical for setting and refining the design space. However, the various stakeholders differ under various aspects, such as knowledge and skills, but also willingness to participate in the project (Duysburgh and Slegers, 2013; Scaife and Rogers, 1999; Vasalou and Khaled, 2013). How these could be involved in the design process, and how these could contribute - considering also practical factors - are arguments that should be studied more in depth. Some authors complained a lack of focus on the design process (de Freitas and Jarvis, 2006; Hall et al., 2013; Moser et al., 2014b), but works discussing these aspects are still limited. A central element of the design process of games for a purpose is the game itself, and the stakeholders' contribution should not be limited to the purpose (by domain experts) and the evaluation of the product (by players). To develop a proper design of games for purpose, it is mandatory to understand more deeply how the different stakeholders can contribute, how their contribution relates to the design of the game - in terms of a playful and effective experience - and how these factors can shape the actual design process.

5. EVALUATION

The second part of the process focused mainly on the evaluation of Skies of Manawak. In spring 2016 the general design of the game was defined according to the information collected in the previous stages. From a practical perspective, the implementation was at 60% of the expected product. Before the release of the first complete version in autumn 2016, the designers planned an expert evaluation to verify the compliance of the main mini-games to the cognitive training and later a beta testing to identify eventual bugs and glitches of the video game.

5.1. Expert evaluation (formative)

In June 2016 the development team completed six mini-games (*Rekenanangi*, *the flight*, *fishing, security system, energy panel* and *meteors and islands,* subsections 3.5.1, 3.5.2, 3.5.3, 3.5.4, 3.5.5, 3.5.8) out of the ten planned for the official release of the game. An expert-based evaluation was organized to verify that, according to a sample of clinical therapists, the mini-games fulfilled the cognitive requirements. This procedure provided the first scientific evaluation of the project. The assessment involved a group of six experts from ODFLab. Participants had no previous knowledge of the game nor took part in the initial workshops. ■ The experts played individually for about thirty minutes each, testing the six mini-games. A tutorial for each mini-game was provided and the difficulty of the game was set to a low level to ensure that the experts focused on the mechanics of the game.

■ At the beginning of the evaluation session, the researchers provided a questionnaire containing six identical questions, one for each exercise. The question asked to identify which EFs were trained for the specific exercise, presenting a multiple-selection list. The experts had to answer the question at the end of each mini-game, identifying the trained EFs and providing further comments. At the end of the session, the researchers run a short interview with the whole group to gather additional feedback in a collective discussion.

Table 5 summarizes the collected data, showing the responses of the six participants according to the EFs associated to each mini-game. Results were very positive. All participants identified the correct EF in the exercises designed to train only one function at the time, and the ones exercising two EFs at the same time were correctly scored by at least 67% of the sample at worst. However, in general participants tended to identify a much larger number of EFs than expected.

Table 5. The answers collected during the expert evaluation, showing the number of answers (cell) for an EF (row) for a specific mini-game (column). In black are highlighted the target EFs.

EF \ mini-game	Rekenanangi	The flight	Fishing	Meteors & islands	Security system	Energy Panel
auditory working memory						
visual spatial working memory	6	1	2	2	5	2
short-term memory	2				1	
auditory sustained	1	1				
auditory selective attention						
visual sustained attention	3	4	2	2	6	
visual selective attention	2	4	6		2	2
attention shift		1				
split attention		4		6	2	1
response inhibition					1	
planning	1	2		1	1	6
other						

The heterogeneity in the responses for the Rekenanangi can be partially explained by the difficulty of providing an unambiguous operational definition of some EFs. For example, during the post-test workshop participants engaged in long and animated discussion to delineate the ontological space of working memory. The different opinions partially justified the variance in their answers, although we could not exclude that the stimulation provided by the mini-games did affect multiple EFs at the same time.

The main goal of the expert evaluation was the theoretical validation of the functional component of the design of Skies of Manawak. The assessment was considered as a pre-validation, where the clinical therapists confirmed the suitability of the mini-games in terms of the neurocognitive requirements. This confirmation allowed to move to the final stage of the development of the game.

5.2. Beta release

The development continued during summer 2016. From June to October the visual artist and the programmer[4] implemented a set of new game elements and refined the existing ones. Firstly, they developed the remaining four mini-games planned for the official release, *the call*, *the falling island*, *shell game* and *shooting gallery* (subsections 3.5.6, 3.5.7, 3.5.9, 3.5.10). In addition to the forest - the environment of the first part of the game - two new ones were added: glaciers and deserts. Each environment had a village that the player could explore to receive new missions and buy new upgrades. An introductory cinematic was created in order to present the prologue and the story. The tutorials were revised and fine-tuned for each mini-game according to the feedbacks and observations from the evaluation. A text-to-speech audio clip was created for each dialogue, providing a full dubbing of the game.

The programmer added the save and load feature. The system was set to automatically manage the saves; this would allow only the loading of the last save point to guarantee a constant progression in the game (Barendregt et al., 2013).

[4] The author.

Finally, the game integrated the registration of the performances for any mini-game (e.g., duration of the mini-game, wrong answers, number of trials) and any game session; this data could be sent at run-time to the database of a central server. At the end of summer 2016 a beta version of the game was ready for testing.

5.3. Beta Testing

The second edition of the Dyslexia Awareness Week allowed a beta testing of the new release of the game. Like the previous year, a series of events was organized at regional level; however, the overall event was not managed directly by the research group of the University of Trento and no school was involved.

Skies of Manawak was showcased across a weekend during a public event; the game was presented to parents during a seminar and could be tested by players on four computer workstations. The workstations were available for almost twelve hours, distributed on the weekend. ■ Like the previous year, due to the large number of visitors, on these two occasions the collected data came from observations by the researchers. At this stage, the focus of the observations was on the overall experience and any possible bug or glitch that could disrupt it.

In general, the players enjoyed playing the game. This was demonstrated by their engagement and the desire of most of them to continue playing beyond the available time, set to 20 minutes for each child. More importantly the tutorials proved to be more effective when compared to the previous versions. Even if some players still struggled to understand the rules of some mini-games, most of them were able to play on their own without requiring any help from the researchers.

◆ From a technical point of view the beta testing highlighted a few issues related to portability. The game was developed and tested by the developers on macOS. The beta testing was on Windows machines. This version presented some bugs (e.g., no support of interaction via mouse) that were promptly identified and fixed.

5.4. Final Evaluation (summative)

As final stage of the design process, the team planned a summative evaluation with children. The objective was to assess the effectiveness of the game in terms of the cognitive training and the player experience. It is important to note that the evaluation was not directly aimed at measuring the improvement in reading and writing skills in dyslexic children, but mainly its effects on EFs in children with developmental trajectories within the typical range.

The main goal of Skies of Manawak was to provide a complementary tool in the treatment of dyslexia, starting from the assumption that the training of EFs could positively influence reading and writing skills. For this reason, before assessing the effectiveness of the game in terms of the effects on reading and writing skills, a validation of its efficacy as a tool for cognitive training was considered as a mandatory step. In order to have a scientifically valid assessment, the cognitive scientist set a real training path.

5.4.1. Procedure

The evaluation of Skies of Manawak was structured according to basic requirements set by the cognitive scientist of the design team. In order to collect a significant amount of data, the main prerequisite was to select a sample of approximatively 40 children attending primary school and 40 children attending secondary schools. Part of the prerequisites was to consider participants with no severe conditions of socio-cultural or linguistic disadvantage and neurological or sensory disorders, visual and auditory. The selected group included four classes (N = 91) of two Italian schools[5]: one class of the third and one of the fourth grade of primary school (equivalent to KS1, years 3 and 4); one of the first and one of the second grade of secondary school (equivalent to KS2, years 6 and 7).

No student was excluded from playing the game. The sample comprised children with and without learning disabilities; however, the performances of the former group were not considered in the data processing. This selection of data was

[5] In Veneto, a region adjacent to Trentino.

applied for methodological rigour: according to the related literature (section 3.1), children with learning disabilities tend to be overly affected by this kind of intervention. Therefore, their performances would have (positively) influenced the results, biasing the outcome of the evaluation.

Teachers were informed a few weeks before the training - set to the third week of October 2016 - and planned the activities together with the cognitive scientist. Parents were invited to attend a series of meetings aimed at providing detailed information on the training path. Each parent (or guardian) signed an informed consent.

A pre-test was administered to each participant at the beginning of the training. The cognitive assessment was used to determine the starting cognitive profile in terms of reading and writing skills and EFs. The pre-test had a simple structure: the cognitive scientist organised a 20-minutes individual meeting with each child, who was tested according to a set of tests (Table 6) commonly used in clinical settings. For this phase, the cognitive scientist was supported by two other scientists of ODFLab, each one managing one third of the sample. The selection of the tests took into account age norms, with the basic idea that the entire batch would have not been excessively tiring for children.

■ The game sessions were held during school time for two hours a week, for a total of six weeks. This structure was designed starting from the assumption, supported by the literature, that an intensive training would have been more effective. The cognitive scientist followed the twelve hours of play, observing and sometimes helping the players. The direct intervention was necessary for gameplay issues (e.g., misunderstanding of instructions) or technical problems. On the latter, the cognitive scientist was instructed by the programmer to solve common problems, such as the procedure after a crash occurred. For more complex issues, a continuous communication with the rest of the team allowed for resolution in a relatively short time, usually in time for the following game session. In some cases, teachers participated to provide additional support.

Table 6. Summary of the batch of tests used for the pre and post-tests.

test	objective
DDE-2 (Sartori et al., 1995)	Reading test of isolated words and non-words to measure reading and writing skills.
MT (Cornoldi and Colpo, 1998)	Reading test to evaluate correctness, speed and comprehension of text.
Attention bells (Biancardi and Stoppa, 1997)	Time trial for the measurement of selective and sustained visual attention skills.
Digit span (Mammarella et al., 2008)	Test for the evaluation of visuo-spatial working and short-term memory.
Spatial span (Mammarella et al., 2008)	Test for visuo-spatial working memory, similar to the digit span test.
TOL (Fancello et al., 2006)	Test for the assessment of planning skills.

◆ During the third week, the lead designer (and programmer) participated in order to observe the players, support them and identify any possible glitch or bug. In this regard, as it will be described in subsection 5.4.2, some glitches were strongly related to the computers running the game. The intervention of the designer was necessary because of the inability to replicate the errors on the computers used for the development of the game.

After the twelve hours of training playing Skies of Manawak, a post-test was administrated to each participant to determine the overall improvement in terms of reading and writing skills, and EFs. The post-test test had the same structure and same batch of tests (Table 6) of the pre-test.

■ Regarding the evaluation of the player experience, the designers planned the distribution of two questionnaires. The first questionnaire was handed to children at the beginning of the fourth week, at the mid-point of the training period. This was composed by only two questions taken from the eSFQ (Moser et al., 2012):

the funometer and the multiple choice question *How would you define this game?* presented in subsection 4.5.3. The main concern of the researchers was that the children could get bored after the first game sessions. The purpose of the questionnaire was to collect a first assessment of the player experience to later verify a potential change in the appreciation of the game.

The second questionnaire (APPENDIX, from Figure 44 to Figure 47) was distributed at the end of the training. The structure was based on the eSFQ and reflections on the data collected from the demo evaluation (section 4.5). As the mid-term questionnaire, the new questionnaire started with the funometer and the multiple-choice question. A second part had a set of closed questions on general engagement (e.g., *would you like to play a second episode?* or *did you feel bored?*), similar to the ones used for the demo evaluation, but reworded to simplify the questions; the cognitive scientist, suggested the addition of closed questions on the self-assessment on potential improvements on attention and concentration, which could be later crossed with the performance data. The next part of the questionnaire provided a set of closed questions aimed at identifying the most liked, disliked and difficult mini-games, with the possibility to add a comment. The questionnaire closed with an open question to collect suggestions for improvements. These last two parts of the questionnaire (APPENDIX, from Figure 45 to Figure 47) aimed at gathering more information on the perceived quality of the mini-games for a future version of the video game.

5.4.2. Run-time redesign

◆ During the first weeks of the evaluation the programmer released a series of updates in order to provide a more reliable version of the game. The computers in the schools' labs were obsolete and soon showed some problems in properly running the game. In order to attenuate the limitations caused by the hardware, a light version of the game was deployed after the first session. Moreover, the development environment proved to be not perfectly reliable on the portability of the game; some players, depending on the computer and the operating system, faced unexpected behaviours. For example, a few computers partially rendered the

game elements, leaving part of the environments invisible. This, and other glitches, were fixed in short time in order to provide a complete experience for all the players. These problems could not be anticipated. In fact, contacting communities of developers it was soon clear that similar glitches happened to a very small percentage of programmers.

✚ Beyond the fix of glitches, other updates concerned the general design of the game. This not only gave the opportunity to provide a smooth experience but also an evolving experience; in fact, most of the comments of the players were noted by the cognitive scientist, were discussed with the other designers and integrated in following updates of the game. In particular, during the first sessions some players found the interaction with the merchant quite confusing, due to the complexity of the interface. A new version of the interface (shown in subsection 3.4.3, Figure 10) was implemented for the subsequent session and was much appreciated by the players. Another example is the reward system. Initially, the rewards were directly added to the resources at the end of each mini-game. In one of the updates a dedicated game screen was added (shown in subsection 3.4.3, Figure 9) for a more explicit representation of the reward, which - as observed by the cognitive scientist - gave a new challenging stimuli to the overall experience.

✚ Another important update concerned the difficulty level. The initial level was too high for the classes of the elementary school (e.g. too many symbols to remember during the Rekenanangi). This issue was particularly relevant in the third grade class due to an unusually high percentage of students with language difficulties and/or special educational needs, who struggled to overcome the mini-games. In this regard, during the first sessions the cognitive scientist observed episodes of frustration. The programmer changed the game to provide a lower initial level of difficulty, balanced with the skills of the players.

5.4.3. Results - cognitive training

The collected data were analysed[6] comparing the pre and post-test means applying multiple paired t-tests. To counteract the problem of multiple comparisons, a Bonferroni correction on 16 multiple comparisons was applied. Considering the lack of a control group, this choice was considered appropriate, where other analysis (e.g., ANOVA) would have provided similar results.

Table 7 shows the results according to the means and standard deviations of the batch of exercises, the statistical significance of the paired sample t-test between the pre and post-test (where the *p-values* were multiplied by 16 according to the Bonferroni correction), and the Cohen's *d* effect size. Each exercise is described by its name and the reading/writing skills, or the specific EF associated to it. All the data were standardized as *z-scores* according to age and scholastic level of the reference Italian population; any value between -2 and +2 standard deviations can be considered as a non-deficit result.

In regard to the reading and writing skills children generally improved. The results showed a statistical significance in the exercises on reading of words both in terms of speed (pre-mean = -0.26, post-mean = 0.22, p = 0.000, d = 0.574) and accuracy (pre-mean = -0.29, post-mean = 0.08, p = 0.000, d = 0.571), reading of non-words in terms of speed (pre-mean = -0.26, post-mean = 0.29, p = 0.000, d = 0.040) and accuracy (pre-mean = -0.10, post-mean = 0.22, p = 0.000, d = 0.394), writing of non-words (pre-mean = 0.02, post-mean = 0.51, p = 0.000, d = 0.610), and reading of text in terms of speed (pre-mean = -0.02, post-mean = 0.47, p = 0.000, d = 0.554). The accuracy of text reading showed a favourable statistical trend (pre-mean = 0.09, post-mean = 0.28, p = 0.064, d = 0.327), while the writing speed of non-words, showed a slight average improvement, but not a relevant statistical significance.

[6] Data were analysed through SPSS, version 22.0.0.0.

Table 7. Means and Standard Deviations of the exercises administered for the pre and post-tests, the statistical significance of the paired sample t-test between the pre and post-test, and the Cohen's *d* effect size.

	pre-test		post-test			
exercise	mean	SD	mean	SD	sig.	d (Cohen)
words speed (reading)	-0.2622	0.86850	0.2200	0.81048	0.000	0.5740
words accuracy (reading)	-0.2943	0.73663	0.0851	0.58195	0.000	0.5715
non-words speed (reading)	-0.2681	0.75562	0.2976	0.71835	0.000	0.0400
non-words accuracy (reading)	-0.1078	0.87539	0.2219	0.75022	0.000	0.3940
words writing (writing)	0.1774	0.86884	0.5081	0.76551	0.224	0.13998
non-words writing (writing)	0.0284	0.84749	0.5192	0.75697	0.000	0.61088
text speed (reading)	-0.0232	0.75971	0.4755	0.86848	0.000	0.55438
text accuracy (reading)	0.0970	0.60757	0.2839	0.53169	0.064	0.32743
comprehension (reading)	0.2328	0.73137	0.2873	0.91810	9.216	0.06567
bells #1 (visual selective attention)	-0.0927	0.97535	1.4571	1.35831	0.000	1.15408
bells #2 (visual sustained attention)	-0.1272	0.90054	1.1570	0.50187	0.000	1.76398
digit span #1 (auditory short-term memory)	-0.5873	0.83770	-0.4560	0.95941	3.728	0.14579
digit span #2 (auditory working memory)	-0.2387	0.88932	-0.4277	0.98535	1.840	0.20138
spatial span #1 (visual short-term memory)	-0.2783	1.35808	0.2179	1.25262	0.064	0.37983
spatial span #2 (visual working memory)	-0.1795	1.09675	0.3292	1.11308	0.016	0.46225
tower of London (planning)	-0.1047	0.94338	0.8261	1.00344	0.000	0.74213

effect size: d = [0.2 - 0.5] small; d = [0.5 - 0.8] medium; d = [0.8 - 1.3] large; d > 1.3 very large

Globally all players improved in the examined cognitive functions. The results showed a statistical significance in the exercises on visual selective attention (bells #1, pre-mean = -0.09, post-mean = 1.45, p = 0.000, d = 1.154) visual sustained attention (bells #2, pre-mean = -0.12, post-mean = 1.15, p = 0.000, d = 1.763), visual working memory (spatial span #2, pre-mean = -0.17, post-mean = 0.32, p = 0.016, d = 0.462) and planning (tower of London, pre-mean = -0.10, post-mean = 0.82, p = 0.000, d = 0.742). The exercise on visual working short-term memory showed a favourable statistical trend (spatial span #1, pre-mean = -0.27, post-mean = 0.21, p = 0.064, d = 0.379), while the two exercises on EFs based on auditory stimuli recorded slight changes on average, but no significance.

The data from the pre and post-tests showed to be considerably positive. Moreover, considering the primary objective of evaluating the efficacy as cognitive training tool, the results on reading and writing skills were quite surprising. The data demonstrated the efficacy of the training of EFs, but also showed a clear distant transfer (transfer of training to non-trained functions) to reading and writing skills. Although it was not yet possible to unequivocally prove the efficacy of Skies of Manawak as a support to the treatment of dyslexia, the evaluation suggested that the game could meet this goal.

5.4.4. Results - player experience

The data from the questionnaires provided interesting information about player experience. The following presentation of the results focuses on the final questionnaire. In fact, the researchers did not find any particular difference from the mid-term questionnaire. For example, the funometer recorded a mean of 4.32 out of 5 in the final questionnaire, where a t-test for non-matched samples revealed no statistically significant differences between the two questionnaires (p-value = 0.63). Similarly, there were no statistically significant differences in the level of appreciation between males and females (p-value = 0.45).

In general, the answers were analysed in relation to the open questions (APPENDIX, Figure 45, Figure 46 and Figure 47). Children's comments were transcribed, grouped by common themes (e.g., frustration for the frequent

repetition of the fishing mini-game, section 3.5.3) and discussed with the cognitive scientist. The latter crossed this data with her personal observations of the game sessions, thus allowing the team to enrich the information about the player experience.

The general perception the game (*How would you define this game?*) was positive. Figure 30 shows the answers of all the players (N = 91): *fun* and *fantastic* were the most chosen positive items; *difficult* and *tiring* were the most chosen negative ones. Figure 31, Figure 32, Figure 33 and Figure 34 show the answers divided by class. The appreciation of the game decreased inversely to the age, with the older students choosing an almost equal amount of positive and negative items. These results could be related to the observations by the cognitive scientist, who pointed out that in secondary school many students took part in the training not motivated by a real interest but considering it as an alternative to the normal school routine.

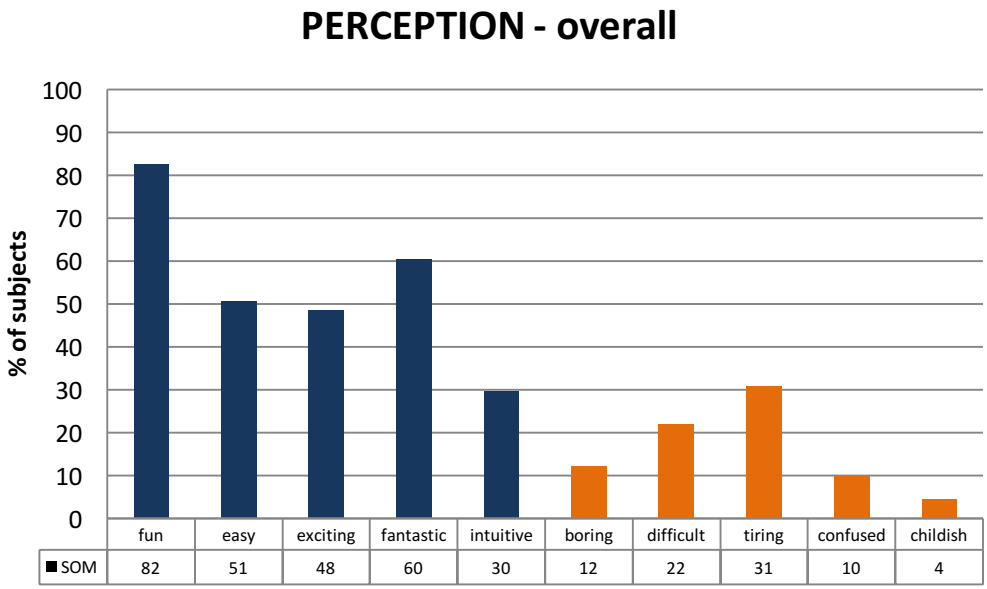

Figure 30. Overall positive and negative items of the perception question on Skies of Manawak.

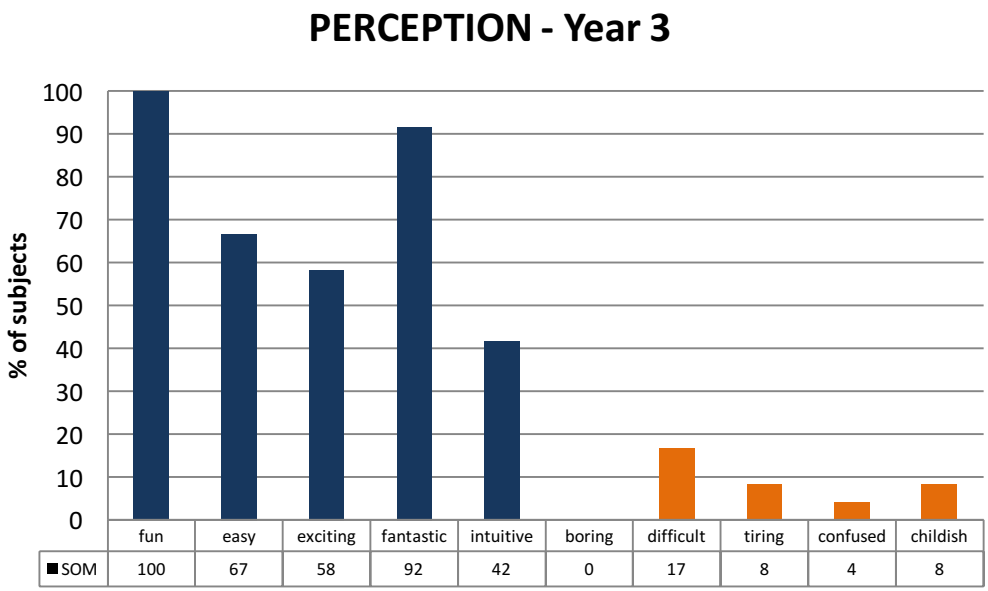

Figure 31. Positive and negative items of the perception question on Skies of Manawak for the Year 3 children.

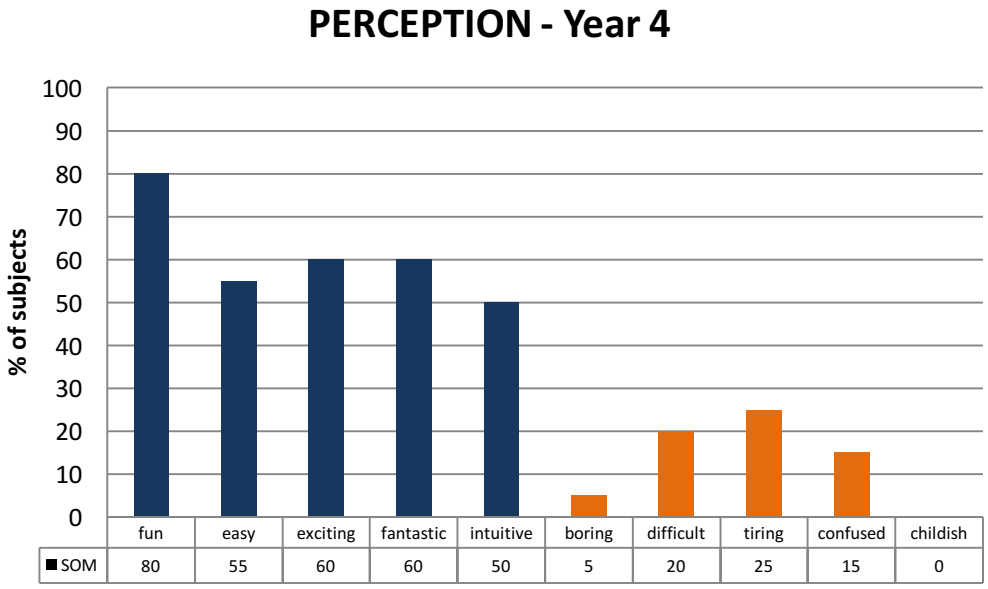

Figure 32. Positive and negative items of the perception question on Skies of Manawak for the Year 4 children.

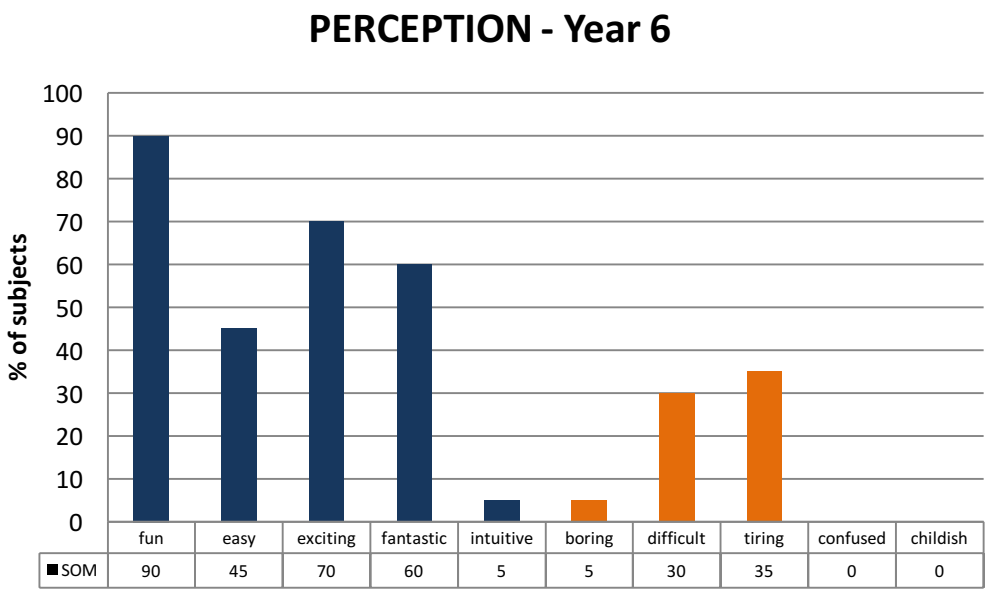

Figure 33. Positive and negative items of the perception question on Skies of Manawak for the Year 6 children.

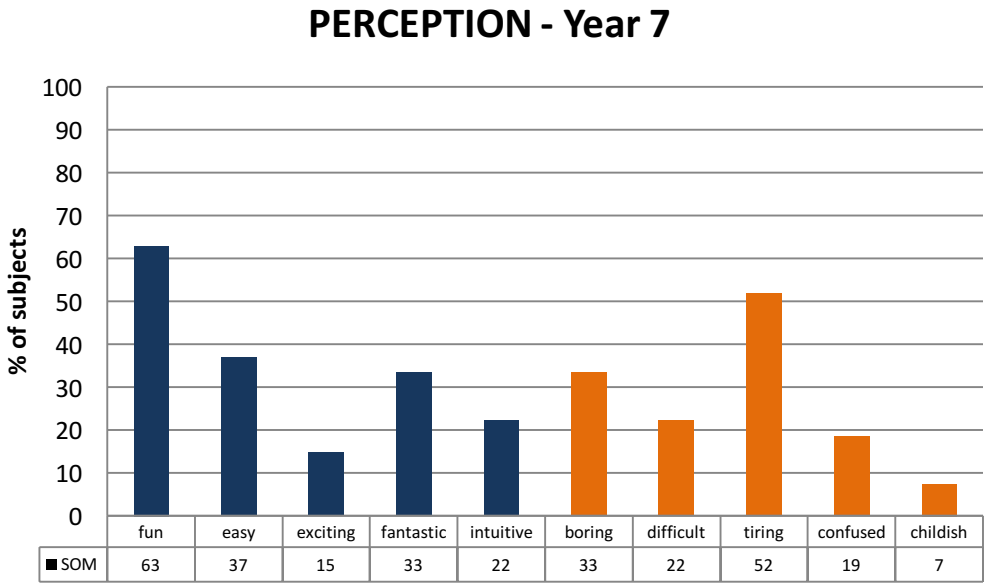

Figure 34. Positive and negative items of the perception question on Skies of Manawak for the Year 7 children.

The results from the questions on engagement also proved an overall appreciation of the game. Table 8 shows the questions and the average response. Players found the game relatively difficult, but nonetheless challenging and not too boring. They expressed a general interest with respect to the advancement of the adventure and they appreciated the aesthetics. Many players would have suggested the game to a friend, but above all a high percentage (about 95%) expressed a strong desire to play a second episode of the adventure. As regards the self-assessment, results were generally positive but they will not be discussed, not being particularly tied to the player experience[7].

Table 8. Questions and related means of answers on the appreciation of Skies of Manawak.

question	**mean (0 = no/never, 2 = yes/often)**
Would you suggest it to a friend?	1,67
If you could take it home, would you like to play it?	1,53
Would you like to play to a second episode?	1,94
Was it difficult?	0,78
Did you like the graphics?	1,74
While you were playing, were you curious about what could happen next?	1,79
Was it challenging?	1,41
Did you feel bored?	0,64
Compared to the beginning, do you feel to be more competent in playing this game?	1,89

[7] This data will be crossed in the near future with the pre-test, post-test.

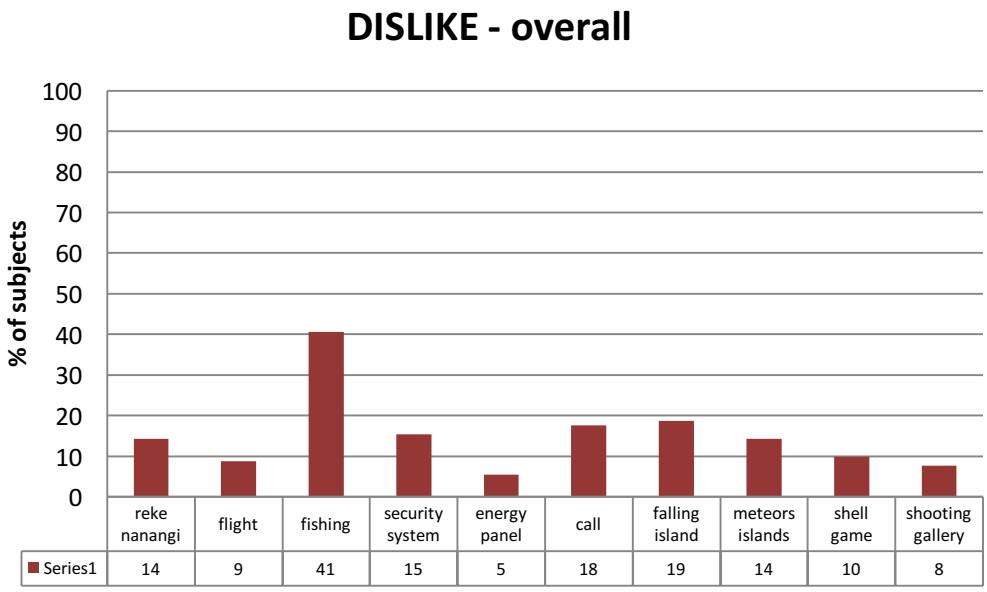

Figure 35. Overall answers to the most disliked mini-games.

In regard to the mini-games, Figure 35 highlights the fishing (subsection 3.5.3) as the only one that was particularly disliked. Even though the fishing shares the same mechanics with the shell game (subsection 3.5.9), the latter was not perceived negatively by most of the students. The cognitive scientist attributed this difference to the setting of the two mini-games. The fishing mini-game is activated every time the player loses all the health points during the flight (subsection 3.5.2) sessions. The less skilled players ended up playing the mini-game more frequently, causing a disruption to the flow of the game session. The shell game was set on the secret island and was particularly appreciated due the mystery and secrecy that enriched the overall experience.

The mini-games that the players liked the most, as shown in Figure 36, were the flight and the energy panel (subsection 3.5.5). The flight was appreciated due to its variety (e.g., various types of sentinels) and the type of challenge, less tied to cognitive exercises and more similar to other action video games. Almost 70% of players liked the energy panel, mainly because of the ability to freely experiment with various solutions and observe the chain of reaction.

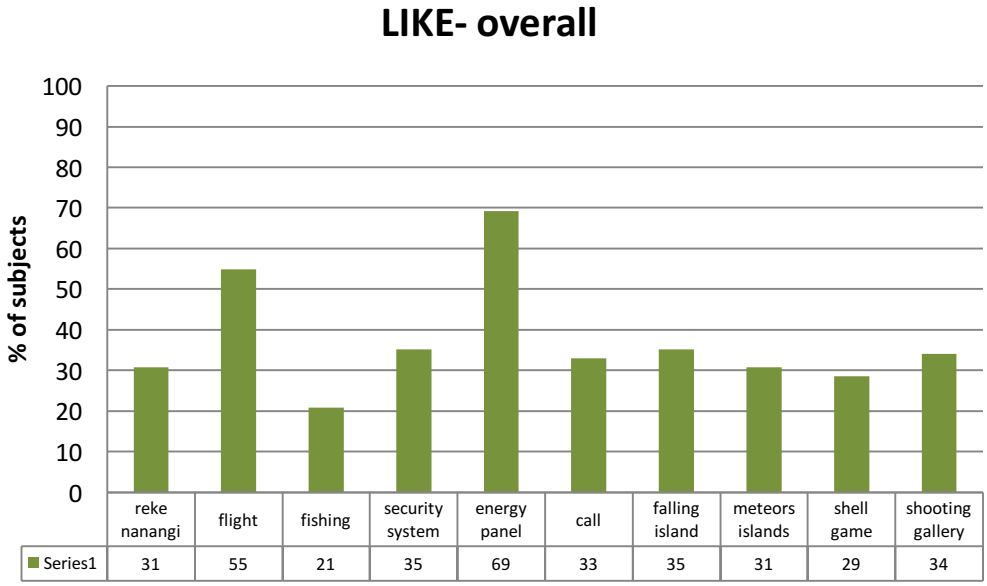

Figure 36. Overall answers to the most liked mini-games.

The most difficult mini-games, as shown in Figure 37, were the security system (subsection 3.5.4) and the energy panel. The security system was quite complex and the players on average struggled to memorize the combination and the path of answer. As for the latter, the players found the latest puzzles quite demanding; in some cases, they applied a simple trial-and-error. Nonetheless they strongly appreciated the mini-game for the freedom to experiment their own solutions.

Additional analysis on the correlation of the various results did not provide noteworthy information. The only exception was in the correlation between the players disliking the flight mini-game and identifying it as one of the most difficult ($t = inf$, $df = 88$, p-value $< 1.2e^{-16}$, $cor = 0.96$). Any other correlation on liked, disliked and difficult mini-games had no significant result.

The last question of the questionnaire (*Would you have any suggestion for the second episode of Skies of Manawak?*) stimulated the players to propose various ideas. Without going into details, the players' proposals focused on the *reward and the customization features*. The children expressed a strong desire to receive a greater number of rewards; these rewards should not only be used to boost the characters, but also their appearance. Beyond that, they suggested *additional content* such as new characters, vehicles, enemies and environments.

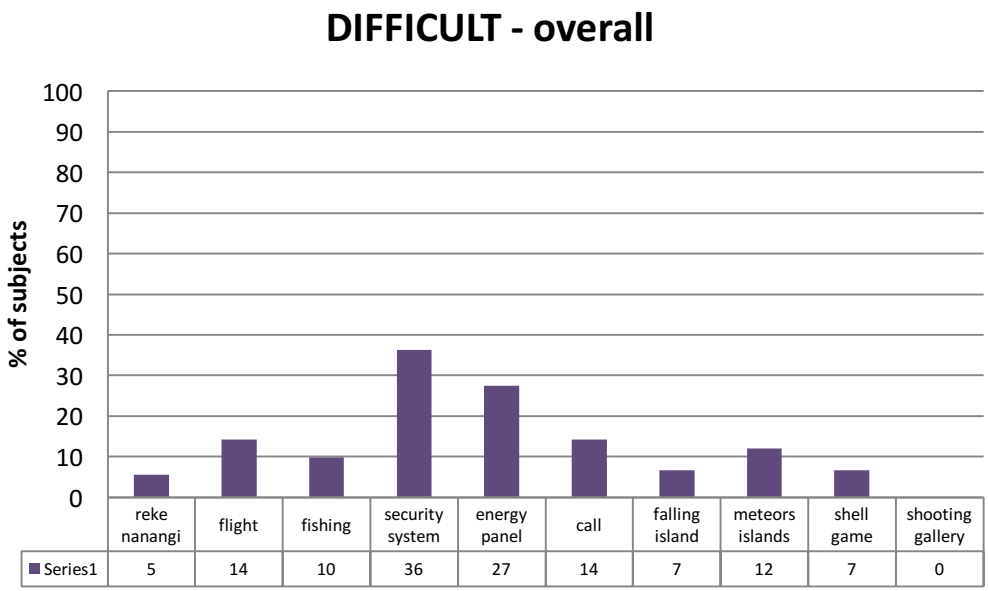

Figure 37. Overall answers to the most difficult mini-games.

The observations provided information related to the answers of the questionnaires, but also additional insights on the player experience. A first remark concerned the skills of the younger players. In the third and fourth grade the children were missing the pre-requisites for computer use. This resulted in a general difficulty using the keyboard, especially the coordination of multiple fingers (e.g., moving the Raku using the directional arrows) and hands (e.g., moving the Raku with the right hand, while pressing the fire button using the left hand). For these reasons, the difficulties, regardless of those in the game, were also in the interaction with the machine (Maertens et al., 2014). Compared to secondary school classes the primary school students had a lower resistance to frustration and a lack of ability to stay focused on the task. They sometimes required the intervention of the cognitive scientist for support and acknowledgment of the skills of the players to strengthen their sense of accomplishment.

Overall, the players were positively engaged in playing Skies of Manawak. The redesign of the merchant and the reward system benefited the experience. The secret island and the variety of environments were particularly appreciated and softened the sense of repetitiveness of the structure of the training. In this regard,

many players did not fully understand the story; the structure of the game was perceived as a mere continuous repetition of the mini-games.

Skies of Manawak was appreciated, but the length and repetitiveness triggered boredom in the less interested players, mainly in secondary school. Players expressed the need for more immediate rewards (e.g., more prizes and more varied ones) and a greater customization of the content. A fact in favour of the positive experience was the request by many players, mostly in primary school, to have a copy of the game to take home.

5.4.5. Problems and reflections

■ ◆ Similarly to the demo evaluation discussed in subsection 4.5, the implementation of the training included a lot of extra tasks and problems, differing substantially from the theoretical planning. The first commitment of the cognitive scientist was to obtain the collaboration of the schools. This task was quite demanding due to the people involved. In order to have a first permission to organize the training, the heads of the schools were contacted and informed in detail about the project. As a second step, each head identified a reference person in charge of approving the project. After the second approval, a few teachers were identified and the cognitive scientist could discuss on the availability of the classes and could start organizing the activities.

◆ The initial communication was complex not just in terms of the number of people involved but also in terms of the quality. Most of the time the information was communicated in fragmented superficial pieces resulting in a sort of *Chinese whispers* effect. For example, the first meeting with the head of the primary school took almost one and half hours to explain in detail all the activities related to the project. However, a week later the cognitive scientist learned that the teachers understood from the head of the school that the project was about filming a video with the students about a physical game for the treatment of dyslexia. In general, the first part of the activities took more than one month, including the time required to contact, inform and receive the approval of parents/guardians.

◆ Another problem was related to the availability of the classes in terms of time. Considering the teaching schedule, taking more than twelve hours required a sacrifice by the teachers. Particularly in primary school, classes had various projects set a few months before. The discussion between teachers and cognitive scientist only one month in advance resulted in a disruption of the planned school activities. As a rule of thumb, it would have been more suitable to involve the schools at least one term in advance. In this regard, both the fifth grades of primary school and the third grades of secondary school were not available due to other projects related to the final exams.

◆ The scheduling of the training sessions had some complications related to the indisposition of a few teachers. In this regard, the teachers responsible for the third grade class at the primary school were not willing to define a fixed schedule of the activities. Each week the cognitive scientist and the teachers had to negotiate the hours, causing a chain reaction with the training sessions scheduled for the other classes. After the third week the researcher had to oblige the teachers to fix a schedule, threatening otherwise to quit the training activity.

◆ Regarding the relationship between teachers and researchers, the former established an implicit *do ut dest* agreement with the latter. Throughout the six weeks of training the cognitive scientist provided informal advices regarding the neurocognitive profile of the children and participated in official talks between parents and teachers.

◆ Another point concerned the technical aspects of the training. As discussed earlier, a first limit was imposed by the computer labs. This was not only affected by the performance of the computer, but also by their number. In primary school the computers were a little less than the total students; therefore, the researchers provided a few machines. In secondary schools the number of computers was much lower and a few students were asked to bring their own machines. In this regard, it was necessary to remind the students several times to bring their laptops and their personal headphones.

5.5. Conclusion

The stages described in this chapter were devoted mainly to the evaluation of Skies of Manawak. However, the results did not only enrich the design of the game and validate its effectiveness as a training tool, but also brought new useful information on the design process.

The evaluation with domain experts provided a new perspective on the game. Although a cognitive scientist was part of the team, the involvement of other external experts provided new useful data for the redesign. This further strengthened the usefulness of stakeholders' intervention, again showing how these could differently participate - depending on elements such as role and capabilities - in the design (Moser, 2013).

In this regard, at this stage of the process players were involved in two occasions, with different roles and conditions. In the open event, children simply tried the game, allowing a testing very close to the beta testing of commercial video games. Although this participation did not have a strong methodological foundation, it provided information both on the overall design and on most practical game bugs. Perhaps this stage represents more than others the need for such actions in the development of these games (Moser et al., 2012). Considering the complexity of design, and the complexity of organizing a well-structured evaluation (Barendregt et al., 2013), this type of activity represents an additional tool to enrich the process. This tool should not replace structured evaluations, but it could help designers refining the design at a relatively low cost of resources.

The last stage of this part, and last stage of the whole process, had the main goal of evaluating the effectiveness of Skies of Manawak as a training tool and as a video game. The results obtained confirmed the achievement of these goals, and led to new findings on the process, primarily on the role of stakeholders. In this case, the domain expert of the team dealt in first place with the design and management of the evaluation. Throughout the whole project, her role was multi-faceted, providing counselling on the purpose, working of the design of the game, supporting players' participation, and eventually becoming manager of part of the

process. What particularly characterized this stage was the integration of practices learnt from the other members of the design team. The cognitive scientist did not only focus on the evaluation of the product in terms of training, but also observed the experimentation from a designer perspective and managed various issues out of her expertise (e.g., fix of minor errors during gameplay), thanks to the knowledge base shared with the rest of the team (Vasalou and Khaled, 2013).

Children once again proved their value as design informants (Scaife and Rogers, 1999), but also revealed the complexity of their involvement. The need of acknowledgments of some and the low commitment of others, are just a few examples of the variety of behaviours observed during the evaluation. The general impression of the cognitive scientist was that, due factors such as young age and the habit of a subordinate role, establishing a peer relationship with children could be a very long and demanding path, even more considering the school context (Iivari and Kinnula, 2016).

Overall, the difficulties were not limited to the players' engagement, but also the organization and management of the evaluation, revealing a number of practical problems. For example, the relationship with teachers was not always positive, leading to a more or less direct influence on the evaluation process. Again, these issues prove the usefulness of documenting facts that are not strictly related to the theoretical bases of the design of games for purpose, but which are fundamental to the definition of a methodology in line with the context.

The format of this manuscript, much longer than journal articles or conference papers, allowed documenting the process and the description of the game in its entirety. One element that this report highlights is the strong interconnection between the game, the purpose and the people involved. Each one of these is fundamental and strongly influences the design process. The formalization of these elements and their interdependence is essential for the definition of a design process that could lead to the development of a valid game for a purpose; this is the main goal of chapter 6.

6. DESIGN FRAMEWORK

This chapter presents the G3P (Game and Purpose, People, Process) a framework for the design process of video games for purpose. The framework emerged from action research and integrated with the literature, following both top-down and bottom-up approaches: the analysis of the related work grounded the framework (section 2); the various design activities held during the development of Skies of Manawak (sections 4 and 5) completed it.

The framework came from the need to formalize the design process of these video games. The research on this topic is usually centred on the evaluation of the game in terms of its purpose and, in some cases, of the player experience. What is often overlooked is the design process of the game; research that provides an overview of the process is limited - some examples (Dodero et al., 2014; Gerling et al., 2012b; Moser, 2013) - and this fact has been already lamented by previous studies (Khaled and Vasalou, 2014; Laporte et al., 2013; Moser et al., 2013).

In this regard, the development of Skies of Manawak outlined a number of fundamental and critical elements. The participation of domain experts and players led to essential contributions. These contributions were gathered in a variety of ways (e.g., meetings on game conceptualization with domain experts, game ideation workshops with players) and influenced the design in several ways. The training purpose affected the overall design, but without compromising the playful component. Each stage allowed not only to enrich the game design, but to acquire new information on the influence of various stakeholders and on the overall development of the design process.

The G3P is intended to formalize these essential elements of the game design process and clearly define their interdependence. As it will be explained in detail in the following sections, this framework is divided in three elements:

1. The definition of foundations according to the **game** and the **purpose**;
2. The identification of the relevant **people** and their participation;
3. The processing of these two elements in a multi-faceted design **process**.

The G3P does not provide detailed information on the process, but a general structure. The framework takes into account the complexity and diversity of the design of video games and it is proposed as a general solution that could be applied to the development of video games of different type, purpose and context of application.

The elements of the G3P are presented in the next subsections, each starting with the most general form of the framework and identifying specific aspects that could be modified and/or extended by other designers depending on the grounding of their research. The second part of each subsection describes the elements from the point of view of the development of Skies of Manawak to provide a practical application of the framework.

6.1. Game and purpose

The game and the purpose are the first elements of the framework. As extensively discussed in the previous chapters, games for purpose should be designed to provide a playful and effective experience. To obtain this result the designers should consider the two as equally important goals (Marsh, 2011). They must be the foundation of the design process and should be considered at every stage.

First, designers should define a basic structure of the design of the game. This structure must be the reference point for the development and should represent a guide element for the entire design process. The game design model may come from those in the literature (Cuschieri et al., 2014), or an extension of these (Gerling et al., 2012b), or could be developed by the designers themselves. In any case, it is important to identify the game design framework in the early stages to structure the design process around it.

The second critical element is the purpose, which is the second mainstay of the design process. The purpose usually implies the necessity for a distribution of knowledge. In fact, in most cases, game designers cannot have a complete overview of the domain, and it is very likely that they do not have in-depth knowledge of the purpose; this usually implies the involvement of domain

experts. Similarly to the game, the purpose is an essential element that must be considered from the initial stage and throughout the design process.

The design of Skies of Manawak was mainly developed around the elemental tetrad proposed by Schell (Schell, 2014). This reference model provided a clear and effective deconstruction of the structural elements of video games. More precisely, this case study was based on an alteration of the original framework, adding a fifth element: the *purpose*. The elemental tetrad became a pentad (Figure 38) where every element was balanced to support the harmonic and parallel development of functional and ludic qualities.

The extension was made necessary by the specific nature of games for purpose, which added several unique functional requirements to the design. As Becker asserts, games for purpose have a component of "what we MUST learn", or in this case study of "what we MUST *train*" (Becker, 2012). In some cases this component is intrinsic, with the game itself as a source of knowledge in the sociocultural perspective of Gee (Gee, 2003, 2010). In many other cases, such as that of cognitive training, the purpose is a separate element defined by specific rules that the design should follow to ensure the effectiveness of the game. Every decision affected by the purpose may influence the other elements and should be carefully considered in the design space.

The pentad was considered as a reference point in the design of Skies of Manawak. For example, in the conceptualization and selection of mini-games, the pentad allowed structuring the dialogue of designers and domain expert around common concepts, where, for example, cognitive exercises were decomposed into their basic mechanics and game scenarios were also analysed in relation to the purpose. During the game ideation workshops, Schell's tetrad was used to refine the structure and to analyse the results. However, the pentad was used to evaluate the consequences of children's proposals on the overall design. The pentad supported the definition of the activities of the design process and guaranteed a balanced development of the game design.

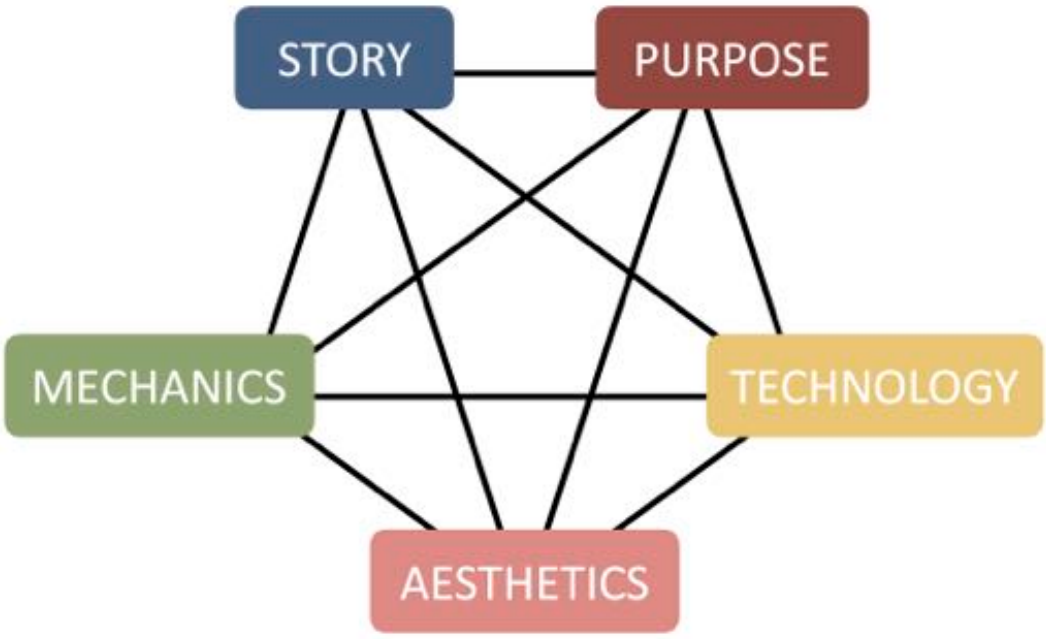

Figure 38. The elemental pentad.

6.2. People

In games for a purpose there is wide space for user involvement, including all the people that could influence (directly or indirectly) the design. As previously discussed, various researchers, including the author, acknowledge the fact that the involvement of the stakeholders is important (Khaled et al., 2014). In fact, designers do not have the same experience or expertise of the stakeholders. While there may be exceptional cases, generally game designers have a partial vision, given by a gap of information on the domain.

People are essential to fill this gap (Gerling et al., 2012a; Khaled and Vasalou, 2014) and they constitute the second element of the framework. In order to develop an effective design process, it is necessary to identify the relevant people and understand their possible contribution to the design. In this regard, the identification of the stakeholders is not the sole step. It is necessary to understand their general role: how they could potentially be interfaced to the project; what relationship they have with other stakeholders; what influence they could have on the design.

Another element that needs to be identified is their knowledge. Knowledge is not purely their level of education, but their knowledge as it relates to their main role in the design process, and knowledge related to other potential roles. For example, the domain experts have a clearly defined role and their essential knowledge concerns the domain and the purpose; to involve the experts in participatory game design activities would require ascertaining their knowledge about video games and game design.

The definition of roles and knowledge is critical to delineate the contribution of stakeholders in the design process. In a participatory approach this contribution must be translated into an involvement. The designers must therefore define methods and tools in order to enhance the participation of the stakeholders. This must be done considering what could be their effective contribution.

In regard to the case study, the elemental pentad helped to define how the designers, the domain experts, and the players could contribute to the various elements of the design of Skies of Manawak. To have a perspective more oriented to the stakeholders, the elemental pentad was integrated within the three stages of game consumption proposed by the MDA framework (Hunicke et al., 2004) as illustrated in Figure 39. This integration was used to structure the involvement of players and domain experts, identifying the most cost-effective spaces for dialogue between the designers and the specific stakeholders.

The players are the direct users of the game, who, in the view of Hunicke and colleagues (Hunicke et al., 2004), look at the game prioritising the aesthetic value. Even if the concept of aesthetics in the MDA framework has a less pragmatic connotation than that of the elemental tetrad, it emphasises the main interest of the players. Aesthetics and story, as defined by Schell, are the key elements of interests to the players: they are primarily concerned with the look and feel, the experience of the game, and they generally do not pay particular attention about how the mechanics contribute to it. Furthermore, any involvement related to the mechanics would require substantial effort for a transfer of knowledge between designers and players in order to develop the necessary common ground (Khaled

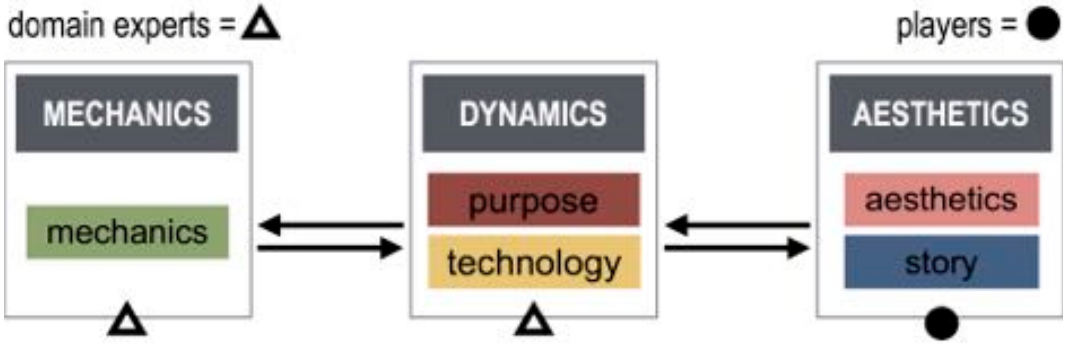

Figure 39. Stakeholders' involvement in relation to the MDA framework and the elemental pentad.

and Vasalou, 2014). The transfer of knowledge would not just require time but also the commitment of the players to engage in this process (Dodero et al., 2014).

It may be easier to discuss with the player about technology, but the choices on this element may be constrained by other design requirements which could not be open to discussion (e.g., distribution: it is possible to reach a broader audience with a computer or mobile game than with a console game). In this view on games for purpose (Marsh, 2011), the purpose shouldn't be a matter of concern of players; it must be an integral part of the game and the players should not perceive it as a separate element (Breuer and Bente, 2010).

In the design of Skies of Manawak the dialogue between players and designers took place at a high level, the aesthetics of the MDA, and concerned primarily the aesthetics and the story and how these elements shaped the player experience. For example, the players participated to the game ideation workshops and provided the fundamental game elements on which the designers could start working. They suggested imaginary worlds, futuristic space travels, heroes and foes. They provided some suggestions on crafting and upgrade systems, but often in a quite generic way, more related to the look and feel of these features than the specific game mechanics. The designers elaborated the information at a lower level, the mechanics of the MDA, and developed a first design of Skies of Manawak. Similarly, in later stages the players played the game and provided feedback based on their experience; all this information was once again decomposed by the designers and translated in code and assets.

The domain experts are the stakeholders who best know the goals for which the game is developed. The main design element that involves them is the purpose. Without the contribution of the domain experts, the designers can only rely on assumptions, which could lead to catastrophic effects on the effectiveness of the game. When the parties have a dialogue about the purpose it is necessary to integrate it into the game and this can be done primarily through the mechanics. A participatory analysis of the game mechanics can be facilitated by a structured process of matching the structural components of the functionalities related to the purpose (e.g., cognitive exercises) into game mechanics, which are then transformed into dynamics and aesthetics. Whether exercises for training or learning, these must be analysed and a protocol should be defined to translate their rules in game mechanics. The main participation space for experts and designers unfolds on mechanics and dynamics, focussing specifically on purpose and technology. Following the assumption that all game elements are interrelated, it is reasonable to assume that those related to purpose, mechanics and technology will also impact aesthetic and story. However, outside of this implicit influence, the domain experts should not take direct decisions on these elements, or at least not in the early stages of the process; instead, this should be left to players.

In the design of Skies of Manawak the dialogue between domain experts and designers initially covered the purpose and, if required, the technology. This discussion took place at an intermediate level, the dynamics of the MDA, focussing on in-game emerging behaviours and rules (e.g., useful strategies for the training of specific cognitive processes). In this case, the elaboration of the information to a lower level was performed both by the designers and the domain expert; the participation of the latter was necessary to ensure a correct elaboration and verify the validity of the process. From the first groundwork to the final release, the domain expert of the design team participated to the design of the game, always considering to balance any change in terms of the purpose.

Parents and teachers were not core participants of the case study but, depending on the context, could contribute to the design of the game. These two stakeholders

have a strong bond with the players, so they know their preferences and are good observers of the ecological environment. They are responsible for the growth of the children and are concerned about what they should and should not learn.

6.3. G3P

The G3P (Figure 40) is a framework aimed at structuring the design process of video games for purpose. The main objective is not to provide a series of precise methods for video game development but to formalize the basic structure of the design process. The G3P provides a holistic view of the various components, connecting the game, the purpose and the people in the design process.

Game and purpose are the foundations and have a two-way relationship with the process. On the one hand, the process produces a range of information that enriches the game (e.g., game ideation workshops, section 4.3) and purpose (e.g., evaluations of training, sections 5.1 and 5.4). On the other hand, these two elements constrain the process. For example, in Skies of Manawak the purpose imposed restrictions on the design space, as the exclusion of specific types of

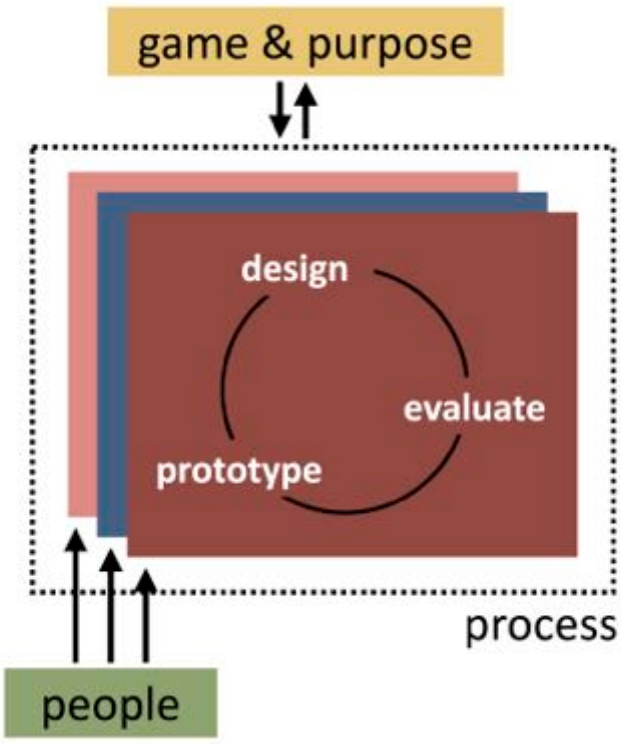

Figure 40. The visual representation of the G3P framework.

games (e.g., game concepts, subsection 4.2.1). This constraint had an impact on the tools, such as the design template discussed in subsection 4.3.1. This in turn had an effect on the game ideation workshops.

People are related to the process as they create various instances, or facets. Each stakeholder has a role and knowledge that characterize her/him, and these factors may determine their contribution and involvement in the process. The difference between the various stakeholders defines how these are placed in the process, and also how they influence it according to their perspective.

In the development of Skies of Manawak, the players were primarily involved in an initial design stage and in a series of evaluations (Figure 41). As the evaluations led to the redesign of various elements of the game, the players covered the role of informants (Scaife and Rogers, 1999). Their involvement was aimed at verifying the validity of the game and collecting opinions and suggestions, which formed the basic material for the game design. Players were not design partners (Druin, 2002) - a limitation that will be discussed more in detail in the next chapter - and their contributions was always elaborated by the designers.

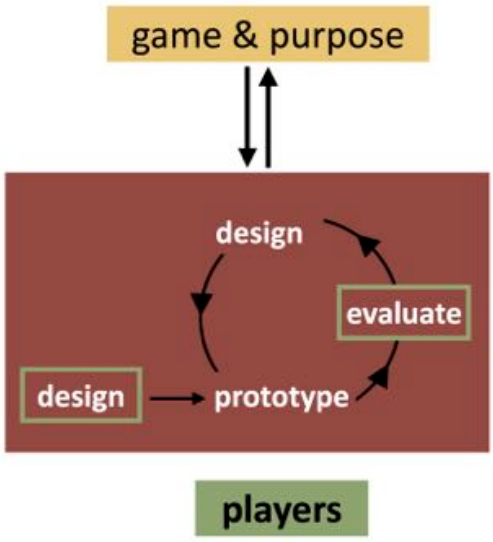

Figure 41. An instance of the G3P from the perspective of the players of Skies of Manawak.

As regards the domain expert, her involvement was more elaborate (Figure 42). In the relationship with the players, she played a similar role to the other designers; her involvement concerned both the organization and management of evaluations and the processing of the collected data into the game design. The share of knowledge with the rest of the team let her acquire a new perspective on game design, thus supporting the processing of information collected from players in terms of the elemental pentad.

In her relationship with the designers as a domain expert her involvement was relatively different. In the development of Skies of Manawak, her contribution was focused on evaluation and elaboration of the design in accordance with the purpose (e.g., selection and design of mini-games), as if the two phases belonged to a single stage of the process. Her contribution allowed balancing the playful and training component according to the specific requirements related to her expertise.

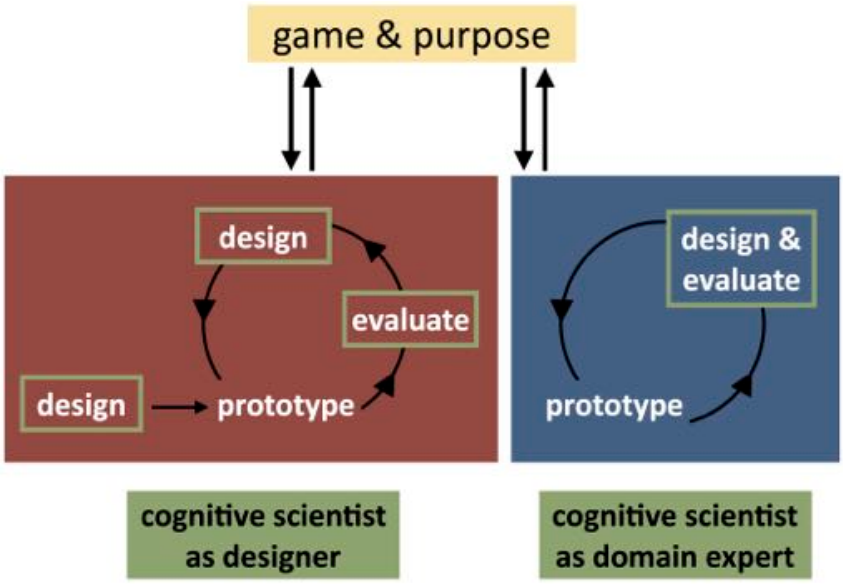

Figure 42. An instance of the G3P from the perspective of the domain expert of Skies of Manawak.

6.4. Conclusion

The main purpose of the G3P is to provide a basic structure for the design process of games for purpose. In its simplicity, the framework came from the need to highlight the importance of the design process. In a research field where the product plays a central role, the development of the game tends to be overshadowed by its assessment (Moser et al., 2014b; Vasalou and Khaled, 2013). In many studies the evaluation is central, unbalancing the design towards the purpose (Marsh, 2011). It is necessary to reconcile these two aspects so that the game is not subordinated to the purpose and vice versa.

The framework is not composed by novel elements, but aims at providing a formal model of the essential components of the design process and their interdependence. Past research exhaustively explored game design, and several recent studies have applied participatory design practices to this subject. However, the design process of games for purpose remains a relatively explored topic, which needs a clearer definition.

The elements that define the G3P identify the pillars of the process, without which the design risks being incomplete. Game and purpose are the central reference, to which the design is oriented. People enrich the design space by filling the knowledge gap of designers. All of these elements revolve around the design process that is influenced by them and, vice versa, influences them.

The G3P formalizes the process in a rather large way, without imposing particular methodological choices. As discussed in the previous section, the main objective of the framework is to support designers in developing a process aimed at a balanced design, which is not dictated by arbitrary choices of researchers or by exaggerated constraints on the purpose. In this, the G3P provides the minimum and essential information generally applicable to the development of games for purpose. The framework underlines the relationship between the various parts but maintains a generic structure applicable to various purposes, game types and stakeholders. The G3P is intended to provide a starting point from which designers can build the process according to requirements and goals. The

framework guidelines are wide enough to allow other designers to develop instances of this framework in accordance with their needs. Using a programming metaphor, the elements of the framework are declarations of variables; the actual value of these variables is what other designers must work on according to the context of their case study.

This does not imply that the tools, methods and game design frameworks described and used in the thesis can not be used as a reference in the development of other games for purpose. For example, the elemental pentad represented the reference framework for the shaping of the *game and purpose* element. Moreover, its integration with the MDA of section 6.2, was used to organize and manage the involvement and contribution of the stakeholders at various stages of the process. Obviously this schema of involvement, where players supported the definition of story and aesthetics and the domain expert supported the definition of the other elements of the pentad, does not preclude a wider participation.

A participation of players as design partners could represent an added value to the process, allowing a deeper discussion on game elements (Dodero et al., 2014). On the other hand, this wider participation, especially with a target group as the one of this case study, could be complex and surely would require additional resources (Iivari et al., 2015; Iivari and Kinnula, 2016), which should not be detrimental for other parts of the design.

The tools and methods applied at different stages of the design process represent another useful resource that could be used by other researchers. As the design process exploited the works of others (IJsselsteijn et al., 2008; Khaled and Vasalou, 2014; Moser et al., 2012, 2014a) and extended them during the development of the case of study (e.g., design template for the game ideation workshops), so other researchers could use the tools and methods described in this thesis. However, while the most generic form of the G3P is of general value, these would be the most dependent to the context.

The freedom to define other instances of the framework through the use of other game design models (e.g., Adams' triad (Adams, 2014)) and a different

participatory approach, places the G3P at a high level of the process. The G3P focuses on defining the design process, where the existing frameworks focuses on the design artefact; thus, these latters become part of the former . Applying the elemental tetrad by Shell (Schell, 2014) rather than the formal game elements defined by Fullerton (Fullerton, 2014) would not change the structure of the G3P. The participation of players as informants (Scaife and Rogers, 1999) rather than design partners (Druin, 2002), or the involvement of other types of users (Gerling et al., 2012b), would have consequences on the design process, which could still fit in the framework. The elemental pentad, the game ideation workshops and other elements of the design process of the case study formed one of the possible instances of the G3P. Introducing the framework the author aims at directing the work of other designers to practices that are consistent with the development of games for purpose, acknowledging the need for a more complete view in order to support the research on these games (Moser et al., 2013).

7. CONCLUSION

The literature shows a clear interest by the academic community on video games for purpose, recognising the high potential for education and training (Breuer and Bente, 2010; Marsh, 2011). However, various studies have implicitly or explicitly highlighted the complexity of these products (Lindberg et al., 2014; Moser et al., 2013; Vasalou and Khaled, 2013). Video games for purpose are composed by many elements, which must be developed harmoniously to obtain a coherent whole. To date, the academic research has led to many valuable contributes, which step by step are enriching the discussion around this topic.

This thesis aimed at the definition of the key elements of the design process of games for purpose, with a particular interest in a mediation between game and purpose and the involvement of the stakeholders. To facilitate this reflection, the author presented a case study aimed at the development of a game for the cognitive training of executive functions for dyslexic children. The development of Skies of Manawak showed how domain experts and players could be involved in a process of game design. This organized approach led to the deployment of a game that was successful in engaging users and robust from a functional perspective.

The design process, the results and all the reflections described in this manuscript, represent a contribution to the discussion of the academic community on these games. It is not a definitive contribution, providing a unique solution to the development of games for purpose; instead this thesis represents a new voice in the discussion, extending the research on the topic. In addition to the reflections presented in the previous chapters, it is necessary to underline a few considerations on the design process, which will be discussed in the next sections.

7.1. Skies of Manawak

Skies of Manawak is a video game for cognitive training, developed through a project lasted nearly two years. During this period, the process was articulated on various stages, each of which led to the enrichment and refinement of the overall design. Each stage was aimed at the development of a game that would have provided a positive gaming experience and would have been effective in terms of cognitive training. The approach to the game design was oriented to the participation of stakeholders, players (8-13 years old) and domain experts (cognitive scientists). Both players and domain experts participated, to a different extent, to the design of Skies of Manawak. Players defined the game idea through the game ideation workshops. Domain experts defined together with the designers the boundaries of the design space and transformed classical cognitive training exercises into engaging mini-games. The evaluations by players, planned at various stages of the process, supported the development and refinement of the game design. At the end of the second year, Skies of Manawak was completed, providing a cognitive training of twelve hours distributed in ten mini-games. At the end of the project the question was whether Skies of Manawak actually met the requirements of an effective an engaging experience.

The final results, as described in subsections 5.4.3 and 5.4.4, confirmed the success of the game. Skies of Manawak provided positive results in the improvement of EFs and also in reading and writing skills. On the other hand, not all the training results proved positive, indicating a margin for improvement. The same applies to the player experience. The data showed a general appreciation of Skies of Manawak, both for the short gaming sessions during the formative evaluations and for the twelve hours training during the summative evaluation. Players were generally fascinated by the game world, with an ongoing desire to explore it. Even in this case, however, not all the results were optimal. In the final assessment, the general appreciation of the game was joined by some complaints, such as the repetitiveness of the mini-games for the older players or the high difficulty for the younger.

The conclusion about Skies of Manawak is that the game was a first success, which would deserve further attention to fully meet the design goals. Each stage of the process actually contributed positively to the development of the game. Where the first evaluations showed some shortcomings in the design, the final assessment showed how the game was near to the desired product. Extending the process to a new design and evaluation would probably take to fully meet the requirements.

7.2. Contribution

The thesis presented the development of a game for purpose, describing the set of tools and methods, and operative suggestions, that characterized the whole design process. The results showed that an approach oriented toward participation has significant advantages on game development but they have also highlighted strong criticalities on the application of this approach to game design, providing new insights on how domain experts and players could be involved. The reporting of the development of Skies of Manawak contributes to the research on the subject by providing new information about the design process. In this respect, the tools from previous studies and those developed for the case study were presented and discussed in relation to their use and their value within the process. Similarly, the participation of stakeholders at various stages was presented and discussed in relation to the contribution to the game design. Finally, the description of the project contained a number of practical considerations on the implementation of the various stages of the process. The description of the process was also aimed at highlighting the strengths and criticalities of the case study, following the request of the research community to document more in depth the design process of these games (Moser et al., 2014b).

The thesis proposed the G3P, a framework on the design process of video games for purpose. The framework decomposes the game development in three interrelated basic elements: game and purpose, people, and process. The G3P provides a design perspective aimed at guiding the planning of the process, adaptable to different contexts and to various research theories. The framework is

enriched, by the application to Skies of Manawak, with the expansion of the elemental tetrad (Schell, 2014) with a new independent game element related to the *purpose* and the integration of this pentad with the MDA framework (Hunicke et al., 2004). The expansion of the two game design framework was presented in relation to the participation of stakeholders and meant to support participatory practices in game design.

7.3. Limitations

The main limitation of this work concerned the conditions of the participation of the stakeholders. The description of the case study showed how a domain expert was involved and became designer of the product, interacting with the game designers as peers. Furthermore, there was a personal growth of both parties (Bergold and Thomas, 2012), where the former gained expertise in cognitive training and the latter in video game design. Conversely, the involvement of players was more complex and more difficult to evaluate. In this regard, previous research studies argued the difficulty of the exchange of knowledge between the designers and the players, particularly considering children as target users (Iivari and Kinnula, 2016; Lindberg et al., 2014; Read et al., 2002).

The role of the players in the participatory process was similar to the *informant* by Scaife and Rogers (Scaife and Rogers, 1999): their involvement was fundamental for a complete overview on the game design space; however, their participation was mediated by the designers, which lastly took the decisions on the game design. A full participation as designer was considered too demanding for the resources of the project; following Khaled's idea, *"if typical players are involved in the game design process in the same capacity as designers, the learning curve will be too steep."* (Khaled, 2012). Still, the author believes that the children implicitly gained new knowledge, through reflection, on game design; however, depending on the context, the resources and the commitment of designers and players, the latter could be true *design partners* (Druin, 2002), ensuring a two-ways exchange of knowledge (Gordon and Baldwin-Philippi, 2014). Such participation could require time and commitment to define a common knowledge

base and set up peer roles (Iivari et al., 2015), but at the same time could create a path of growth for designers and gamers truly in line with the principles of participatory design (Vines et al., 2013).

7.4. Future work

Considering the reflections and limitations of the case study, there are several plans for future development. From a game design perspective, the development team planned new updates with respect to all the elements of the pentad. As for the story, the visual artist and the lead designers planned a second episode that will close the main plot. Regarding aesthetics, new nations (and their villages) will be added and accessories will be introduced to personalize the characters. In this regard, the mechanics will be extended with a customization and a crafting system. At the technological level, Skies of Manawak will be optimized to run on mobile platforms to reach a greater number of players. Finally, regarding the purpose, new mini-games training different EFs will be added.

Designers and domain experts already initiated new evaluations involving subjects of ODFLab with learning disabilities. In this case, the training will be performed at home, without the supervision of the domain experts. Furthermore, a new assessment will involve players outside Italy to study possible differences due to the language.

7.5. Final remarks

The thesis presented various practical reflections on the design process, which the author strongly believes could be very useful for similar works. The difference between a theoretical planning and practical execution can have serious consequences on the success of the project. One of the lessons learned during the design process is that the researchers should consider a degree of flexibility in planning, always taking into account the worst scenario.

Another practical consideration is related to the implementation. This case study looked at the development of a video game from a favoured perspective, where the lead designer was also the programmer. This could not apply for other studies,

and a further division of roles between designers and programmers should be considered. In this regard, one factor that can be crucial is the need to find a compromise between what designers would like to develop and what programmers and artists could actually implement (Vasalou and Khaled, 2013).

A final reflection must be done on the development team of this project. Throughout the very intense and demanding design process, the team developed strong ties, which motivated and supported them. The emergence of a strong team can be attributed to the participatory-oriented approach of the design process. The constant process of mutual learning, begun during the grounding meetings and progressed throughout the process, quickly blurring competences and responsibilities of individuals, making Skies of Manawak a truly participatory artefact. This process was facilitated by the fact that the domain expert had a previous strong interest in video games and the designers were fascinated by the variety of cognitive styles that are well exemplified in dyslexic people.

To conclude, the author would like to clarify once again that one of the main goals of this research was to add a new voice to the discussion on game for purpose. The author strongly believes in the potential of these tools and the need to enhance the discussion with new studies and new theories in order to better shape this wide and complex topic. The hope is that this research will stimulate a further discussion and will inspire other researchers.

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APPENDIX

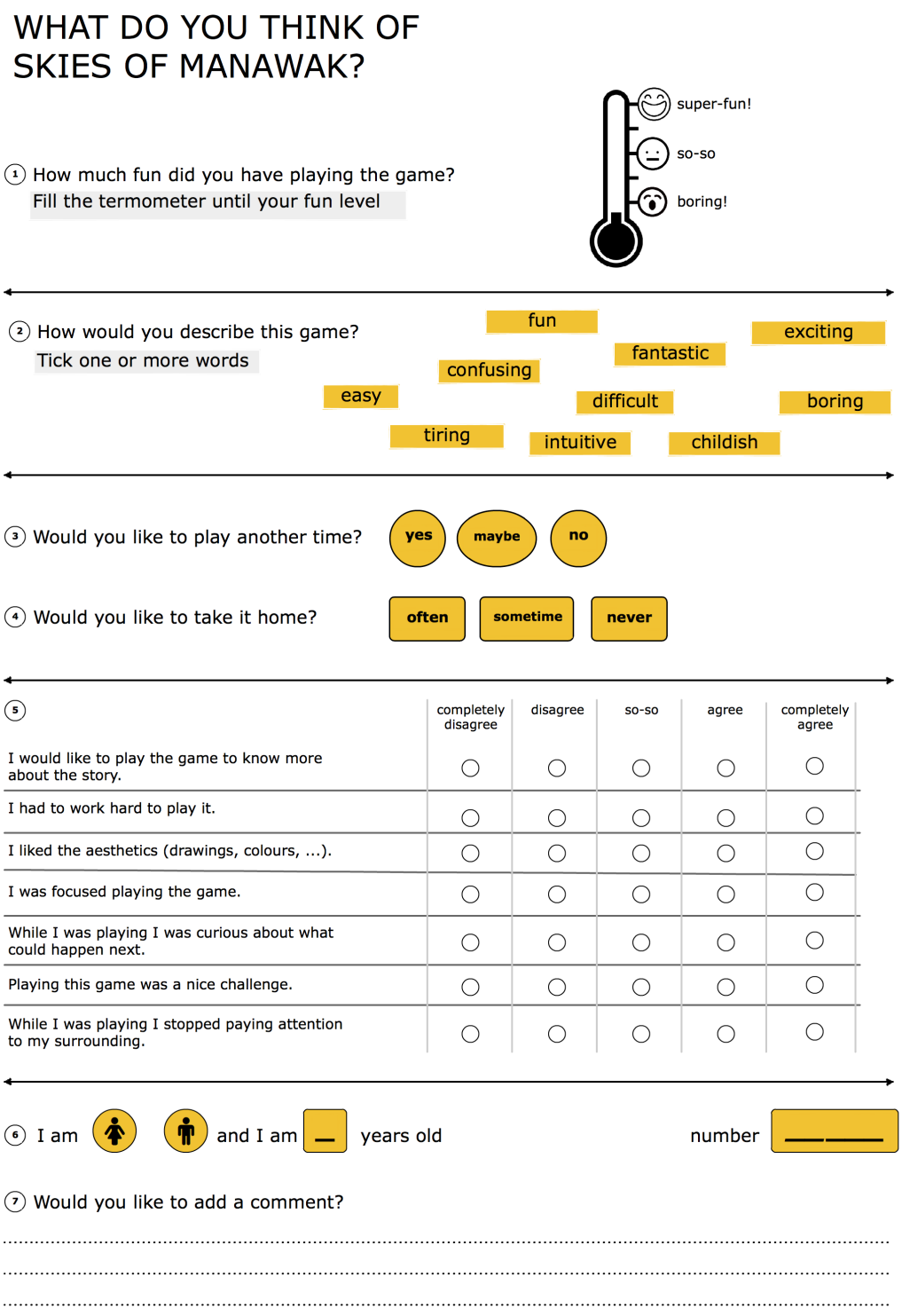


Figure 43. Questionnaire on player experience for the dyslexia awareness week.

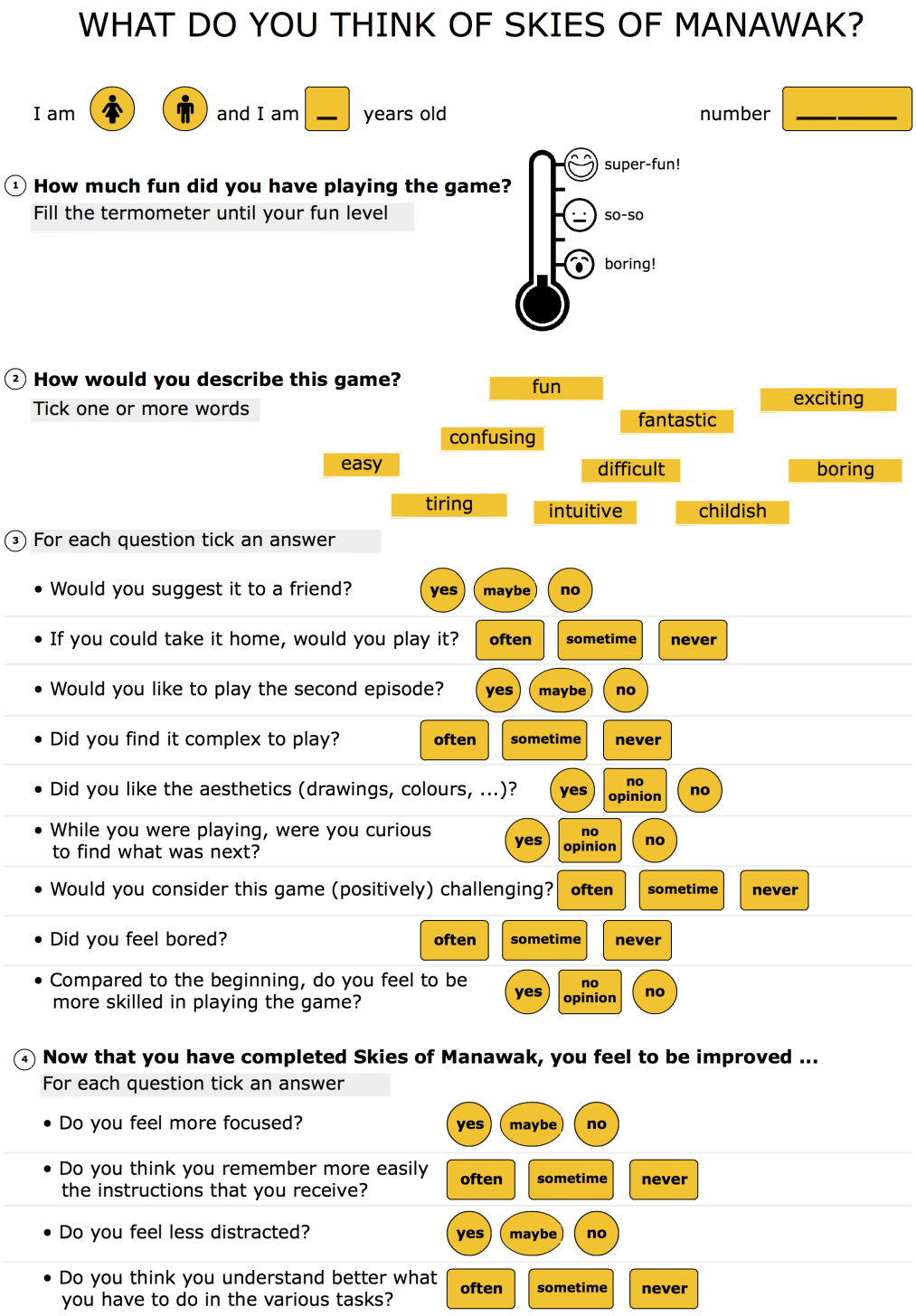
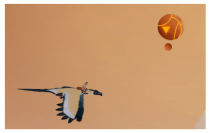
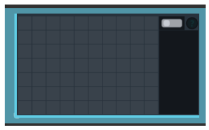
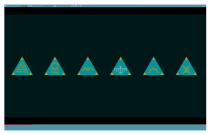


Figure 44. Questionnaire on player experience for the summative evaluation (page 1).

5 What did you NOT like playing Skies of Manawak?

Tick only one box and write your answer below

◯  Flying with the Raku and fighting sentinels	◯  Perform the ritual with the Uka
◯  Calling the Raku on the Tower (sounds)	◯  Solve the puzzle of the tower's panel
◯  Memorize symbols and order of the tiles	◯  Feed the Raku
◯  Jump with the character and avoid the meteors with the Raku	◯  Shooting while sliding only when you hear the right sound
◯  The game of the triangles on the mysterious island	◯  The shooting gallery on the mysterious island

Why? Tell us what you think by writing your answer below

.....

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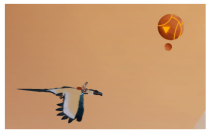
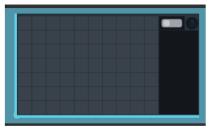
.....

.....

Figure 45. Questionnaire on player experience for the summative evaluation (page 2).

⑥ **What did you like playing Skies of Manawak?**

Tick only one box and write your answer below

◯  Flying with the Raku and fighting sentinels	◯  Perform the ritual with the Uka
◯  Calling the Raku on the Tower (sounds)	◯  Solve the puzzle of the tower's panel
◯  Memorize symbols and order of the tiles	◯  Feed the Raku
◯  Jump with the character and avoid the meteors with the Raku	◯  Shooting while sliding only when you hear the right sound
◯  The game of the triangles on the mysterious island	◯  The shooting gallery on the mysterious island

Why? Tell us what you think by writing your answer below

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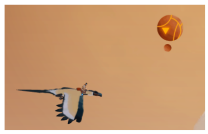
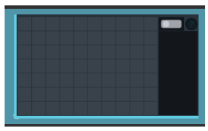
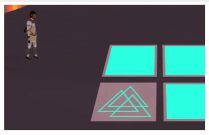
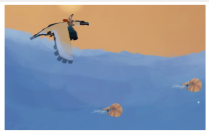
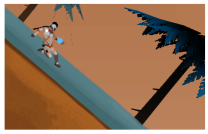
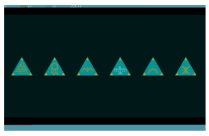
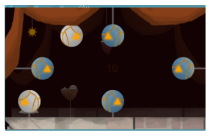
Figure 46. Questionnaire on player experience for the summative evaluation (page 3).

7 What did you find difficult playing Skies of Manawak?

Tick only one box and write your answer below

◯  Flying with the Raku and fighting sentinels	◯  Perform the ritual with the Uka
◯  Calling the Raku on the Tower (sounds)	◯  Solve the puzzle of the tower's panel
◯  Memorize symbols and order of the tiles	◯  Feed the Raku
◯  Jump with the character and avoid the meteors with the Raku	◯  Shooting while sliding only when you hear the right sound
◯  The game of the triangles on the mysterious island	◯  The shooting gallery on the mysterious island

Why? Tell us what you think by writing your answer below

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9 Would you have any suggestion for the second episode of Skies of Manawak?

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Figure 47. Questionnaire on player experience for the summative evaluation (page 4).