Working attention, planning and social skills through Pervasive Games in Interactive Spaces

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Abstract— **Video games can serve as educational tools that make easier the development of creative, critical and communicative skills. After detecting that video games may decrease physical activity and social interactions, real world is coming back to computer entertainment, with a new gaming genre: Pervasive games. These games integrate physical and social aspects of real world, so that they overcome the limitations of traditional games in the spatial, temporal or social dimensions. Interactive spaces are a natural place to deploy pervasive games, as they both share their ubiquitous computing nature. Thus, we have tried to explore the possibility of having pervasive games in interactive spaces playing a role as learning tools, specifically for developing attention, planning and social skills. This way, we have designed a pervasive game to be played in an interactive space to work on those aspects. The game is made up by ten different missions. Also, we have developed an observation and analysis model that allows identifying which processes get activated during the game, and we have carried out an evaluation with the model with the intention of validating the usefulness of the activities and of the model. Lastly, we have obtained some recommendations for the design and mediation of pervasive games in interactive spaces.**

Index Terms—***Pervasive games, Hybrid games, Interactive spaces, PASS model.***

I. Introduction and goals: educational pervasive games in interactive spaces

PLAYING is an enhancer of rationality and logic [1] and is mainly a social activity [2] that makes easier the learning of values and behaviors [3]. Computer games can also serve as educational tools that make easier the development of creative, critical and communicative skills, and also allow working on solving complex problems, taking decisions, and searching for information. Technological advances are making possible the appearance of a great variety of educational computer games, which facilitate motivation and interaction [4]. Both are important features for learning, so it is expected that the use of this kind of games will be greater and greater in the next times [5], [6]. However, computer games may have disadvantages, as they may decrease physical activity and social interactions. In the last years, real world is coming back to computer entertainment, with a new gaming genre: Pervasive games. Pervasive games are no longer confined to the virtual domain but integrate physical and social aspects of real world [7]. Usually, the idea in pervasive games is that they overcome the limitations of traditional games in the spatial, temporal or social dimensions [8]. However, the term has several definitions that set the focus in different issues related to the games. Last years, the focus has been put in the context, and they are defined as a new gaming experience where the dynamics of the game evolves by means of the information provided by the context where it is played [9]. Nevertheless, and even though the ambiguity of the term and its use to refer to very different types of games, there are three common characteristics shared by all of them: (1) the mixing of real and virtual world, (2) the support of natural styles of interaction (voice, tangibles, gestures), and (3) their strong social component.

Interactive Spaces [10] are a natural place to deploy Pervasive Games, as they both share their Ubiquitous Computing nature. Interactive Spaces (IS) are Distributed User Interfaces supporting several ways of interactions in digitally augmented rooms that combine:

--Multiple interaction techniques: a panoply of related interaction paradigms such as Physical Computing, Context-Aware Computing, Mixed Reality, Wearables and Tangible User Interfaces can be combined and converge in an IS, allowing multiple users to interact, at the same time or in a distributed way.

--An heterogeneous multi-display output ecosystem: in an IS, providing feedback to let users know what is happening in the environment can be done by different ways: projection walls, screens, and mobiles that can show visual and audio information to the users, haptic technologies that recreate the sense of touch by applying physical reactions to the users such as vibrations or movements, systems that are able to change the users' taste perception, or even based olfactory devices that display different smells to the users depending on the goal of the application displayed in the IS [11].

Initially, ISs have been applied to explore new possibilities of collaborative work and meeting rooms [12], [13] but more recently they have been considered as the ideal environment for the creation of games [14]. As we will see in the state of the art section, during the last years we are seeing an increasing number of projects and prototypes of pervasive games in ISs.

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Nevertheless, the use of pervasive games with educational purposes in IS is still scarce.

Our hypothesis is that pervasive games in Interactive Spaces may play a role as learning tools. Moreover, as they offer a multi-sensory collocated and motivating learning experience [15], they are a valuable tool for working attention, planning and social skills. In order to test that assertion, we have carried out the following work:

--We have designed a pervasive game to be played in an IS to work attention, planning and social skills with children. The game is made up of ten activities in which different kinds of natural interaction (gestural, tangible, etc.) are used.

--We have developed an observation and analysis model that allows identifying which processes of attention, planning and social skills get activated in each activity of the game.

--We have carried out an evaluation with the aforementioned model with the intention of validating the usefulness of the activities for working the skills and also the usefulness of the model itself for the identification of the processes activated during play.

--From the experience, we have obtained some recommendations for the design and mediation of pervasive games in Interactive Spaces.

In the next sections all details are given. In section 2, a state of the art of pervasive games in Interactive Spaces is presented; in section 3 the theoretical model that sustains the election of learning goals is presented. Section 4 is devoted to explain the work context whereas section 5 details the pervasive game developed. In section 6 an observation model is proposed; its application to the evaluation of the pervasive game created is presented in section 7. Section 8 condensates the new design and mediation recommendations and finally section 9 presents conclusions and future work.

II. State of the art: pervasive games in interactive spaces

When developing pervasive games, it is necessary to augment the game environment to allow the players to interact with the technologies involved in the game. We can categorize the pervasive games in four categories depending on the augmentation carried out: *objects augmentation* (smart toys), *table augmentation* (tabletops), *room augmentation* (Interactive Spaces), or *world augmentation* (outdoor games). Here we will focus in Room augmentation as Interactive Spaces lay in this category; a complete pervasive games state of the art can be found in [16].

The *Kidsroom* [17] is an indoor environment that re-creates a child's bedroom where children become the protagonists of a story. The children have to go asking the different pieces of furniture of the room in order to discover a magic word that would allow them to travel to other worlds. Visual feedback is provided through wall projections that recreate the room environment and the different worlds the children can travel to, and audio feedback is reproduced via several speakers. Four cameras are used to track the children's position and movements.

StoryRooms [15] is a room-size story telling environment designs for and with children to author multisensory storytelling experiences. With the use of low-tech (cardboard, plastic cups, paper) and high-tech (sensors, wireless embedded computers, electronic tags) children build story telling elements to support the authoring of storytelling experiences to be shared with other children.

Touch-Space [18] is an interactive room where players have to walk around and interact with physical objects. In order to track the players' position in the room, *Touch-Space* uses a Real Time Locating System (RTLS) able to detect the position of the head and hands of the players. Players also wear a Head-Mounted Display (HMD) to support video-see through augmented reality feedback, and the HMD has a small video-camera to track visual markers attached to different objects of the room [19]. In addition, the players carry a wand toy that gives visual feedback about the tasks that they have to perform.

Age Invaders [20] is an interactive indoor game installation based on the Atari™ *Space Invaders* classic arcade game. In *Age invaders* the spaceship digital sprites were physically replaced by the players themselves. The floor is digitally augmented with audio and video projection, representing the star background and the missiles that each player shoots. Players use a hand controller to shoot the missiles. When a player is hit, the *explosion* is showed in a LED display that the players wear on their body.

Another mixed reality example is *Treasure* [14], where players have to find objects marked with RTLS tags. *Treasure* has been designed so that it is possible to trigger different digital responses to the player's actions: for example, when they find an object an audio can be played, an image/video can be shown on the wall, or both.

Another game, the *Music Room* [21] is an interactive indoor installation where music can be composed by dancing in the space. In order to detect the dancers' movements, cameras are embedded in the environment and a tracking software was developed by applying digital image algorithms. The composition system analyzes the data from sensors and generates music depending on the way people are dancing (close to each other, far from each other, fast, slow).

Starloop [22] is a game designed to be played in an interactive space containing four tangible tabletops and visual projections in a screen. It consists of several activities designed to introduce programming concepts like loops and procedures to middle school children. Each of the four children teams have to lead their spaceships by using tangible playing pieces that represent commands and that have to be put on the tabletops, that act as control panels. In spite of having an educational aim, no learning gains or impact are measured nor discussed.

In [23] an interactive multisensory environment, MEDIATE, designed for autistic children is presented. The environment provides with real-time visual, aural and vibrotactile outputs and support natural full body interaction thanks to the use of non-invasive sensing technology based on 9 cameras. The aim of the activities designed is to enhance non-repetitive actions, and to work control to help children in the autistic spectrum to achieve a sense of agency.

In [24], a game to learn physics to be played in an interactive

exhibit is presented. *Wobble Board* is a game-base activity requiring body movement and collaboration with other players to accomplish the goal: to lead virtual balls to the holes present in a virtual board projected in a large screen in front of the players. They stand on a 5x5 meter wooden floor equipped with sensors under its surface, where to 12 players can move freely combining their movements. The game is defined with specific learning goals related to physics: to investigate basic concepts such as angle, forces, friction, mass, etc. The evaluation presented is quite complete, combining observations, pre and posttest, as well as interviews. Although fun and engagement result from the evaluation with users, educational gains related to physics concepts were not noticed. The engagement and social possibilities of such an exhibit are clearly shown, but also the need of a more carefully design of the activities if educational goals are pursuit.

As it can be seen, the educational possibilities of IS have been scarcely explored nor the way to integrate the learning goals in the design of the games and in their assessment.

III. Why attention, planning and social skills: The PASS model

If a game is generally a social activity, which favors reasoning and logic, and if pervasive games in interactive spaces mix physical and virtual elements and allow children to move, run and interact among them, it seems logical to think that the educational use of these games can be encouraged. However, it is necessary to consider the users' cognitive, emotional and motivational aspects in the design of the games in order to take advantage of all their potential. In this sense, it is important to start from models that provide a base for the convenience of what it is going to be worked.

The PASS model (Planning-Attention-Simultaneous-Successive) [25] explains what happens in the mind when we process information. This model is built on a brain-based approach to intelligence motivated, and emerging findings of neuroscience research on cognitive processes.

Processing information, is what we do when we learn and the PASS information processing model, explains intelligent behavior through three functional units: attention (first functional unit), codification (second functional unit) and planning (third functional unit). There are two types of codification: simultaneous and successive; and there are three types of attention: arousal, selective and sustained. All these units are closely interrelated. Codification and planning interact to execute several actions and to facilitate knowledge acquisition and, at the same time, both these functional units depend on the existence of an adequate alert state (attention) so that learning can take place.

For learning to be possible, an automatic alert state and a conscious attention process are necessary. In turn, information coding (simultaneous and successive processing) and planning interact to coordinate and facilitate the acquisition of knowledge. Prior knowledge and mediation modulate the way in which the aforementioned processes are activated and used [25]. Therefore, effective processing is carried out through the interaction between planning, attention, simultaneous processing, successive processing and prior knowledge and, of course, paying attention to the task. [26], [27].

Attention is composed of two other processes: one of them is automatic, doesn't require any effort and isn't controlled (arousal); the other process is conscious, requires effort and is related to and depends not only on the attention functional unit but also on the planning functional unit. Arousal is related to being alert, and it can vary depending on external conditions (cold, heat, noise…) and internal conditions (affective and cognitive). Attention has been considered as an essential construct in psychology [28] and during recent years it has been an important research area in the context of learning difficulties [27], [29]. These research studies have focused particularly on selective attention, which allows children to concentrate exclusively on the relevant stimuli, and sustained attention, which is related to the ability to maintain attention for a longer period of time. Technology may play a relevant role in both cases: a careful selection of different types of stimuli may help the child focus attention; and these stimuli may also improve motivation and engagement with the activity.

Planning requires metacognitive skills, awareness and motivation, because it is a mental process through which we can select and solve problems effectively [26]. This means that cognition and behavior must be active and strategic. Planning makes possible the control and establishment of plans, their execution, review of the process followed, and making new decisions if necessary [27].

There is also a strong link between coding and planning, since tasks can be processed in different ways. Selecting simultaneous and / or successive processing will depend on the executive function, the learning experiences, and the demand of the task [26], [27].

The PASS model also considers the effect that emotional processes have on learning (the work of 94), and how motivation can be weakened depending on the attributions that children make of their successes and failures [30]. In that sense interaction and mediation are key issues to improve cognitive and motivational processes, becoming elements that generate learning [31].

Regarding the game as a space for the development of social skills, several research has been carried out, as [32] points out, which support the benefits that can be obtained derived from the use of games for developing such skills. If the child can work the reflection skill about their own learning processes through a social act, this allows him/her to take joint decisions, enriched with different contributions. Moreover, the individual perception of the environment can be improved by sharing experiences with others, since other people can provide different views and perspectives that modify the child's comprehension, influencing his or her decision-making process. For a successful joint action, the aims, knowledge and beliefs of all participants must be considered, sharing them and working in groups and not individually, in order to achieve a greater benefit. In this way, the group thinks only as one and the individual is capable of communicating the thoughts and reflections of the whole group to other people [33]. Moreover,

the interaction and the joint action with colleagues improve problem solving when it is necessary to select data that provide specific knowledge. In this sense, it is essential to promote the interaction between children.

Furthermore, in a globalized world such as ours, learning for coexistence in diversity and cooperation implies an educational challenge for which, as [34] points out, acquiring skills for cooperation is essential. Thus, the European Council [35], highlights eight skills for generating skills for a democratic culture, and among them it proposes working on cooperation skills in order to be effective in interaction with other people.

Digging into this idea, Johnson et al. [36] proposed to create the adequate conditions for cooperative work by working on four skills that are organized as a taxonomy that implies increasing difficulty:

1. Forming: These are skills for creating groups, staying in them, taking care of equipment and partners, promoting participation, etc.

2. Functioning: They are oriented towards making easier the performing of tasks by proposing, accepting, mediating, etc.

3. Formulating: They are oriented towards making learning easier in all members by summarizing, correcting, etc.

4. Fermenting: This is the higher level, and it is oriented towards member to integrate in *academic controversies*.

The work on the two first levels is relevant in the context of children play, being the basic elements over which learning for cooperation can be built during successive stages.

In conclusion, we have seen how working on selective attention, strategic behavior and metacognitive knowledge is the basis of the learning process, in which cooperation has also to be promoted. All these skills were the ones that we decided to work on the pervasive game developed in the scope of the JUGUEMOS project, as it is explained in the following section.

IV. Context: the JUGUEMOS project

A. The JUGUEMOS interactive space

The JUGUEMOS IS [37] is an indoor area of 70 square meters designed as a hybrid-game laboratory to support the exploration and prototyping of innovative interactive games that blend physical with virtual game elements [38]. Its main elements are shown in Figure 1:

--Four NikVision Interactive tabletop (Figure 1.1): a digitally augmented active table capable of displaying images on their surface, and capable of sensing both finger and objects placed on them [39]. The recognition of objects on the table surface is provided by the use of ReacTIVision fiducials [40].

--Kinect devices: they allow tracking users gestures in the IS (Figure 1.2).

--Real-Time Localization System (RTLS) (Figure 1.3): this sensor tracks the users' positions on the IS area. It is based on the use of small active RF beacons whose position is triangulated by four sensor receptors placed on the IS corners.

--Display devices, the IS has three video projector screens (Figure 1.4) that cover the surrounding walls. Also, the tabletop surfaces and the screen of the mobile devices work as displays to show information related to the game.

Games for the space have been developed thanks to the JUGUEMOS toolkit that facilitates the creation of hybrid games for Interactive Spaces [16].

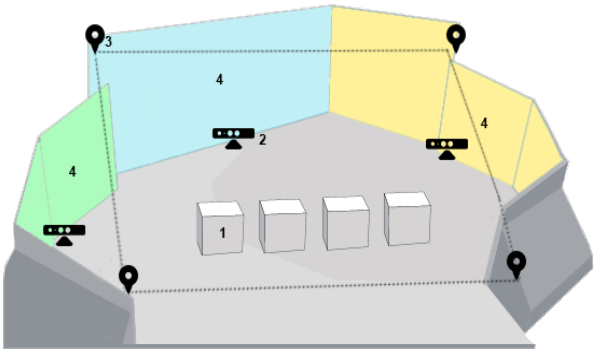

Fig. 1 Interactive Space configuration. 1) Tabletop devices. 2) Kinect sensors. 3) Real Time Localization System. 4) Video projection on walls.

B. Design and mediation recommendations

In the context of the JUGUEMOS project an intensive work defining games for ADHD children was performed, basically activities and games for tangible tabletops. This work resulted in a set of design guidelines and mediation recommendations that are summarized here (see Table 1). More information about them and how they were obtained can be found in [41].

TABLE I
DESIGN GUIDELINES FOR ADHD CHILDREN

G1	The level of difficulty of the game should be adaptable
G2	The objective of the game and how to achieve it have to be clear
G3	The game should help the children be aware of the time
G4	The manipulative possibilities of the tabletop should be potentiated
G5	The game should be totally controllable by the educator
G6	The game should promote the search for information and the identification of alternatives
G7	Positive and encouraging feedback must always be given
G8	Interest and the motivation should be maintained through several stimuli
G9	Games should enhance selective attention
G10	The game should promote collaboration to solve the problems

Although they were extracted from our experience designing games for tangible tabletops, only one of them is really specific to tabletops. In the same way, even though the guidelines have been established taking into account the learning needs of ADHD children, the fact that they favor the development of the cognitive functions relating to planning and attention make them suitable for application to every child or group of children, following an inclusive perspective [42], [43].

One key guideline is number 5: the game should be totally controllable by the educator. The role of the educator as mediator is essential for an effective learning process from our point of view. Mediation is understood as the interaction between the educator and the child in order to guide him/her during the performance of the task. Through interaction, mediators generate opportunities to encourage abstract thinking by favoring new ways to perceive, challenge, and be open to

other options and emphasize the process of change as a physical experience [44]. In their work, Feuerstein et al. [45] differentiate eleven categories or types of mediation (first column Table 2). Suggestions about how to translate these mediation categories into specific mediator's actions can be found in [41].

TABLE II
FEUERSTEIN'S MEDIATION CATEGORIES AND AIMS

Feuerstein's categories	Mediation aim
MR1. ***Intentionality and reciprocity***	To find the meaning of the task and to be actively engaged in order to promote active responses.
MR2. ***Transcendence***	To generate new needs (precision, accuracy, new knowledge…).
MR3. ***Meaning***	To encourage meaningful questioning.
MR4. ***Feeling of competence***	To feel acknowledged, to acknowledge oneself, and to show it with positive stimuli.
MR5. ***Regulation and control of behavior***	To find out a more formal way of sharing: explaining answers, strategies…
MR6. ***Sharing behavior***	To help to analyze and to argue their own answers and to express their own ideas.
MR7. ***Individual and physiological differentiation***	To encourage convergent and divergent points of view and support their answers while noticing how they differ from other styles.
MR8. ***Planning***	To become more flexible by including new information and generating new responses as a result.
MR9. ***Challenge: Search for novelty and complexity***	To acquire flexibility, to include new perspectives and generate new answers.
MR10. ***Structural change***	To facilitate a higher level of abstraction.
MR11. ***Search for an optimistic alternative***	To anticipate the future using the situation in which the children have achieved their objectives. This information facilitates their development.

From our point of view, when designing a pervasive game to be played in an IS, where several children play together in an amazing place with several stimuli, these mediation guidelines become essential to ensure an adequate learning experience. Moreover, the design of the game has to reinforce mediation; the use of virtual character may play an important role in that sense. Nevertheless, in the case of learning experiences in IS, the presence of a person (educator) who adapts, motivates and assures appropriated experiences, is not only needed, but essential.

V. A PERVASIVE EDUCATIONAL GAME: THE FANTASTIC JOURNEY

The fantastic journey is an adventure game intended to be played in a specific interactive space, the JUGUEMOS IS, explained before. The game is of special interest for children with attentional problems but as it works on basic learning skills it can be useful for all children. Next, we are going to describe the game following the schemes present in [46], [47] and the Game Experience Design Document defined on the GeoPGD methodology [48].

A. General information

Core gameplay

During the play, players have to move around the interactive space in order to find objects or to achieve the challenges proposed by the game. They also have to interact with the tangible tabletop devices handling physical tags. Also, in order to pass the challenges, they may need to use the own body or voice.

Main features

In Table 3 we are going to detail the main features of The fantastic journey, with special interest to its pervasive features.

TABLE III
MAIN FEATURES OF THE FANTASTIC JOURNEY

Feature	Description
Genre	It is an adventure game, in which the protagonist has to progress over the story interacting with different characters and objects.
Number of players	It is a multiplayer game, aimed up to 16 players organized in four groups.
Players' characteristics	The game is directed towards inexperienced players that do not need to be familiar with the rules of the game neither with the controls. The age of the target players is from 7 to 12 years old.
Technology requirements	The game must be played in an interactive space that includes: a localization system, microphones, Microsoft Kinect devices, loudspeakers, projectors and tangible tabletop devices.
Aesthetics and art	The beginning of the game takes place in a funfair. The remaining pieces of the story take place at space, where the main character meets other characters and performs different activities.
Summary of the story	The story is about a girl called Pipo, who has a dream in which she puts on a magic hat. With the hat on, she flies into the space, where she meets the Comet of laughs, which delivers laughs all over the universe. During the encounter, Pipo gets lost with the bag of laughs. Then, she decides to travel through the space to find the comet and return him the bag so he can continue delivering laughs all over.
World of the game	The game takes place at both virtual and real worlds, as the story happens at the virtual world but players have to fulfill some challenges at the real world in order to get the story continued. To this effect, the virtual characters in the story will propose the challenges to the players.
Pervasive expansions	This is a pervasive game to be played in an interactive space. The game implements a strong physical pervasiveness, as players have to move around the space and interact with physical objects to advance through the game. There is also social pervasiveness, as players may interact with the people around them. This pervasiveness is not as strong as the aforementioned.

Dynamics of the game

Detailed in Table 4.

TABLE IV
GAME DYNAMICS IN THE FANTASTIC JOURNEY

Dynamics	Implementation
Narrative	All the missions in the game are linked through the story, which justifies the missions and captivate the player within the game.
Progression	The game can be adapted to increase or decrease the difficulty of the challenges in order to match the players' characteristics.
Assessment	When the players achieve the goals of a mission, the game advances to the next one. The mediator can force the finish of a mission if needed.
Action points	As the game is divided in small missions, players have to perform actions continuously.
Emotions	Players may express their curiosity by interacting with the different elements in the game. Competitiveness is not present as it is not a competitive game. On the contrary, sympathy to other players may appear and players may help their partners. As the difficulty may be adapted, frustration should not appear.

Interfaces of the game

Another relevant point that has to be defined in order to characterize the game is which user interfaces it includes. This can be shown in Table 5.

TABLE V
INTERFACES IN THE FANTASTIC JOURNEY

Interfaces	Description
Natural interfaces	There are several: voice interaction, tangible interaction by means of the NikVision tabletops and body interaction by postures, sensed by the location system, and arm gestures caught by Kinect devices.
Communication interfaces	The message exchange among the elements of the interactive space is done by means of a Wi-Fi network. The JUGUEMOS toolkit is charge of the real-time management of the different actuators and sensors present in the IS.
Mobile interfaces	A mobile device given to the mediator allows him/her to control the course of the game.

Educational Goals

The main educational goals that the game aims to achieve are the following (see Table 6):

1) Regarding *attention*: The game is intended to develop participants' focused attention (A_FOC) in one or more sources of information, as well as maintained attention (A_SOS) and/or selective attention (A_SEL) towards those sources.
2) Regarding *planning*: The game is intended to develop the fact that participants explicit their metacognitive knowledge (P_MK) and develop their strategic behavior, with the establishing and fulfillment of a plan to achieve a goal with self-regulation and perseverance (P_SC),
3) Regarding *social skills*: The game is intended to develop participants' skills in ease to create groups, stay in them, take care of material and partners, and encourage participation (S_FOR), as well as skills oriented towards the performing of tasks, proposal making, accepting and supporting rotating leadership, and also mediating in case of a conflict (S_FUN).

TABLE VI
GAME EDUCATIONAL GOALS

Attention (A)	A_FOC	Focused Attention
	A_SOS	Maintained Attention
	A_SEL	Selective Attention
Planning (P)	P_SC	Strategic Behavior
	P_MK	Metacognitive Knowledge
Social skills (S)	S_FOR	Forming Skills
	S_FUN	Functioning Skills

These objectives do not correspond, in this case, to the learning of contents, but rather to the procedural and metacognitive dimensions, contemplated by Krathwohol [49] in the evolution of Bloom's original taxonomic model [50], in which the objectives aimed at learning to learn are contemplated as educational objectives, among other aspects.

The work team has been able to verify through various prior experiences in the IS its high potential to work on cooperation [16]. Besides, tangible tabletops have several characteristics that make them potentially useful in education contexts: sensory engagement, accessibility and group learning. By keeping physical objects on the physical side of the users, the emotional impact of the game is reinforced [51] and important additional benefits emerge when applied to young children [52] and to children with special needs [53], [54], [55]. In fact, NikVision tabletops have been used to work elements such as selective attention, strategic behavior and metacognitive knowledge [41], that are the basis of the learning process, as discussed in Section III.

Design Guidelines

The guidelines presented in Table 1 were taken into account in the design of the game.

G1. The level of difficulty should be adaptable: three difficulty levels have been defined (easy, intermediate and difficult). The mediator will be the responsible of selecting the difficulty level, depending on the characteristics of the players.

G2. The objective of the game and how to achieve it have to be clear. Although the core of the game are the ten educational activities, special effort has been done to construct a narrative that guides the player through the different missions and links each activity with the aim of the journey. Before each of the missions, small videos with instructions given by the main character are played. They can be replayed if needed (mediator).

G3. The game should help the children be aware of time. In those activities where time plays a role the tine left is made always explicit.

G4. The manipulative possibilities of the tabletop should be potentiated. Four interactive tangible tabletops are used and four missions make use of them.

G5. The game should be totally controllable by the educator. The mediator is given a mobile that allows him/her to control all the game, the level of difficulty of the missions, if the instructions are replayed, if an activity has to be repeated or it is finished etc.

G6. The game should promote the search for information and the identification of alternatives.

In the missions the search of information need for subsequent missions is constant.

G7. Positive and encouraging feedback must always be given. After having accomplished each of the missions a short celebration video I shown, and after having accomplished all of them, players are encouraged to celebrate dancing and singing altogether.

G8. Interest and motivation should be maintained through several stimuli. The main character, Pipo, and the narrative try to keep motivation through the game. Information is provided through different channels (oral, images, written, physical objects) and several interaction modalities are supported (voice, tangible, body location and gestures) during the game.

G9. Games should enhance selective attention. It is one of the educational goals of the game and several missions are defined to work it.

G10.The game should promote collaboration to solve the problems. Players are organized by the mediator in four teams, each with one name (of planets), a color and a tabletop assigned. All the teams have to complete the missions to proceed through the game but they do not pass to the following level if all of them haven't succeed. Once a team has accomplished its challenge they are encouraged to help the other teams.

B. Missions of the game

Lastly, we are going to detail the missions which are included in the game. Each one has its own goals, flow, challenges and outcome. All these aspects as well as the specific educational goals and the type of interaction (indicating the IS sensors/components involved) get defined in Tables 7 to 16. At the same time, figures 2 to 10 depict photographs taken during the evaluation sessions. Educational goals are also detailed for each of the missions.

TABLE VII
DESCRIPTION OF MISSION M1-LISTENING TO PIPO'S STORY

Elements	Description
Goals	Players should get to know about the story being told and the general objective of the game (returning the bag of laughs).
Flow	Players place themselves in the IS and follow the story being told.
Type of interaction (IS sensors)	No interaction (none): they do not have to interact with the game nor with their mates at this point.
Challenges	The players have to be quiet and attentive to the story.
Outcome	When the story is told, the *real* missions in each star begin.
Educational goals	Focused attention (A_FOC) and maintained attention (A_SOS).

TABLE VIII
DESCRIPTION OF MISSION M2-ORDERING THE SONG AND DISCOVERING THE MAGIC WORDS.

Goals	Players have to discover the magic words that make the wizards' hat transform into a magic hat.
Flow	The song of the game is played; players have to order the words that make up the chorus using the NikVision tabletops. When the chorus is completed, the magic words are projected in the main wall and players have to say them in loud voice
Type of interaction (IS sensors)	Tangible interaction (NikVision tabletops): The words are physical pieces that are given to the teams (one sentence per team). The pieces are manipulated by the players and put onto the interactive tabletops. The words of the chorus are projected in the main wall as each of the teams place their words onto their tabletop. If the order is OK the chorus is completed.
Challenges	Players have to listen to a song and then order the words that make up the chorus.
Outcome	When the magic words are said, the hat transforms and lets Pipo, and the players, begin the journey to the stars.
Educational goals	Maintained attention (A_SOS), selective attention (A_SEL), metacognitive knowledge (P_MK), strategic behavior (P_SC), forming skills (S_FOR) and functioning skills (S_FUN).

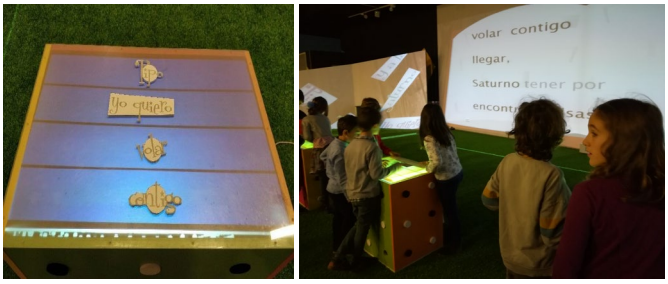

Fig. 2. Photographs of mission M2-Ordering the song and discovering the magic words. Word pieces put onto a tabletop (left). Checking if the order is correct (right).

TABLE IX
DESCRIPTION OF MISSION M3-KNOWING ABOUT THE STORY OF THE SUN AND THE MOON

Goals	Players have to make their bodies fit first the shape of the sun, and, then the shape of the moon.
Flow	The shapes of the sun and the moon are projected on a wall; the players are given necklaces with sensors to follow their positions. They have to move and place themselves so that they fit all in the silhouettes of both celestial bodies.
Type of interaction (IS sensors)	Body interaction (location sensors): thanks to the sensors worn by the players, a point representing each of them is projected on the wall. Players have to move so that all the points fit inside the projected shape.
Challenges	The players have to move and place themselves at the same time in a specific place.
Outcome	The story about the celestial body whose shape has been made up is introduced to the players.
Educational goals	Focused attention (A_FOC), strategic behavior (P_SC) and forming skills (S_FOR).

Fig. 3. Photograph of mission M3-Knowing about the story of the sun and the moon

TABLE X
DESCRIPTION OF MISSION M4-FINDING THE SUITCASE AND DISCOVERING THE CODE

Goals	The goal is to find a suitcase hidden in the interactive space and to open its lock.
Flow	First, the suitcase has to be found. Then, to open the lock present in the suitcase, children play in groups four rounds of the Starloop [22], a game developed to improve computational thinking in kids. Each time a round is completed they are given one of the numbers of suitcase lock combination.
Challenges	Each of the activities introduces concepts related to computational thinking: action sequences, loops, executions…
Type of interaction (IS sensors)	Physical interaction (none): children wander in the IS searching for the suitcase. When they get the code they have to unlock the suitcase. Tangible interaction (NikVision tabletops): players are positioned in front of their tabletops. They are given a set of physical pieces to be put onto the tabletop to play the Starloop game.
Outcome	Inside the suitcase there are physical objects they need for the subsequent missions.
Educational goals	Maintained attention (A_SOS), selective attention (A_SEL), metacognitive knowledge (P_MK), strategic behavior (P_SC), forming skills (S_FOR) and functioning skills (S_FUN).

Fig. 4. Photograph of mission M4-Finding the suitcase and discovering the code: playing the Starloop game

Fig. 5. Photograph of mission M4-Finding the suitcase and discovering the code: unlocking the suitcase

TABLE XI
DESCRIPTION OF MISSION M5-CALMING AND SOLVING THE WORD SEARCH PUZZLE

Goals	To make a calming break, and to discover a word in a word search activity on the tabletops.
Flow	Stars are projected in the main wall, and the text players listen to makes them search for constellations and geometric forms. Afterwards, they are asked to find in groups a word that has been said in the text (star) in a word search that is projected on the tabletop devices.
Type of interaction (IS sensors)	Tangible interaction (NikVision tabletops): the players use physical marbles to identify the letters of the word to be found in the puzzle projected on the tabletops.
Challenges	A word has to be identified in a text listened by the players, and then it has to be located in a word search puzzle.
Outcome	When the word letters are correctly selected on the tabletop, the game advances to the next mission.
Educational goals	Focused attention (A_FOC) and maintained attention (A_SOS), selective attention (A_SEL), metacognitive knowledge (P_MK), strategic behavior (P_SC), forming skills (S_FOR) and functioning skills (S_FUN).

Fig. 6. Photograph of mission M5-Meditating and solving the word search puzzle: searching the hidden word

TABLE XII
DESCRIPTION OF MISSION M6-VISITING THE SIOUX STAR

Goals	The main goal is to free a prisoner made by the Sioux star inhabitants by playing a music sequence with the tabletops.
Flow	An image of the prisoner is projected on one of the walls. The music sequence is projected on the main wall as a set of colored circles that get activated one after another. Each tabletop has been assigned a color and the players get mallets from the suitcase. Players have to reproduce the sequence hitting their tabletops in the correct order on time.
Type of interaction (IS sensors)	Tangible interaction (NikVision tabletops): each team has to be positioned in front of their tabletop with their mallets. The projected circles get activated during a period of time (graphically shown as a completing circle) in which the team has to hit their tabletop. If the time for that color is over the sequence begins again to be played.
Challenges	Players have to reproduce the sequence of colors in the correct order and sufficiently quick. Players of the same group have to hit their tabletop at the same time and coordinated with the other groups.
Rewards	When the sequence is completed, the prisoner is freed and the game advances to the next mission.
Educational goals	Maintained attention (A_SOS), selective attention (A_SEL), metacognitive knowledge (P_MK), forming skills (S_FOR) and functioning skills (S_FUN). .

Fig. 7. Photograph of mission M6-Visiting the Sioux star

TABLE XIII
DESCRIPTION OF MISSION M7-FREEING THE STARS FROM THE GALACTIC WEB

Goals	The goal is to free three stars that have been trapped in a spider web.
Flow	A text containing information needed to free each of the stars is projected on the tabletops. Each team has to read it and memorize the information. To free a star, it has to be combined with the appropriated object. To do so, a player chosen by the team has to select a star and then the correct object. The rest of the team can help giving oral clues. It is done in turns until the three stars are free.
Type of interaction (IS sensor)	Body interaction (Kinect): the objects and the stars are projected on two walls of the IS. One player comes in front of the wall and with his/her hand selects one object and drags it until reaching the correct star. If the pairing is correct, positive feedback is given. If not, the object returns to its initial position.
Challenges	The player has to remember the information read and make gestures to interact with the projection and free the stars.
Outcome	To free the three stars and to advance to another mission.
Educational goals	Maintained attention (A_SOS), selective attention (A_SEL), metacognitive knowledge (P_MK), forming skills (S_FOR) and functioning skills (S_FUN).

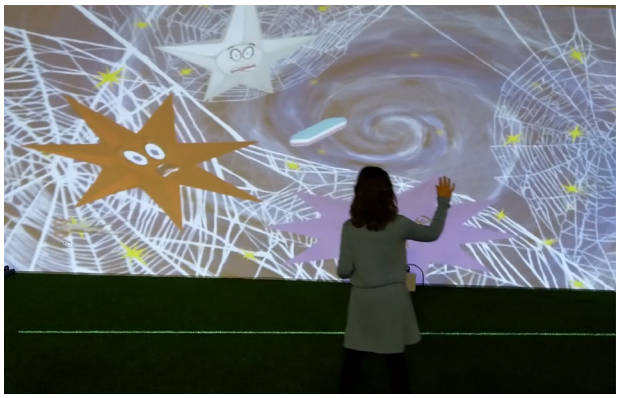

Fig. 8. Photograph of mission M7-Freeing the stars from the galactic web

TABLE XIV
DESCRIPTION OF MISSION M8-DESTROYING THE METEORITES

Goals	The goal is to destroy a group of meteorites.
Flow	Each group of players in a table has to destroy the meteorites that appear in it. This is achieved using physical space ships from the suitcase. There are two space ships per table so they have to use them in turns.
Type of interaction (IS sensors)	Tangible interaction (NikVision tabletops): meteorites are projected on the tabletop. The spaceships are physical pieces with a hole: the player has to put the spaceship on the table and tap with the forefinger in the whole to get the spaceship shoot. The shots appear on the tabletop projection and when they hit a meteorite it bursts into pieces.
Challenges	The meteorites have to be destroyed using the tangible objects.
Outcome	When all the meteorites of all the tables have been destroyed, the game goes on to the next mission.
Educational goals	Maintained attention (A_SOS), selective attention (A_SEL), metacognitive knowledge (P_MK), forming skills (S_FOR) and functioning skills (S_FUN).

Fig. 9. Photograph of mission M8-Destroying the meteorites.

TABLE XV
DESCRIPTION OF MISSION M9-DISCOVERING HOW MANY BUTTERFLIES OF EACH COLOR APPEAR

Goals	To count the number of butterflies of each color projected in the IS walls.
Flow	Some butterflies in movement are projected in the wall. Players must stay quiet so that the butterflies are placed on the flowers and can be counted. If they make noise, the butterflies will move faster and it will be difficult to count them.
Type of interaction (IS sensors)	No interaction (none).
Challenges	Players have to stay quiet so that the butterflies move slower and can be counted more easily.
Outcome	When the butterflies stop, they can be counted and then the game goes on the final scene.
Educational goals	Maintained attention (A_SOS), selective attention (A_SEL), metacognitive knowledge (P_MK) and forming skills (S_FOR)

Fig. 10. Photograph of mission M9-Discovering how many butterflies of each color appear.

TABLE XVI. DESCRIPTION OF MISSION M10-DANCING THE SONG AFTER FINISHING THE GAME

Goals	To see how the journey ends and celebrate its end with the other players.
Flow	The end of the story is projected and the song of the game is played encouraging the players to sing and dance in the middle of the IS.
Type of interaction (IS sensors)	Social interaction (none)
Challenges	There are no challenges in this phase of the game.
Outcome	After this scene, the game has finished.
Challenges	There are no challenges in this phase of the game.
Educational goals	Forming skills (S_FOR)

VI. OBSERVATION MODEL

As a complement to the educational activities designed. we have developed a tool to support the observation and assessment of the educational goals pursued (the ones shown in Table 6). The tool shown in Table 17 is an innovative proposal that allows identifying whether the game is causing the development of attention, planning and social skills, according to the models explained. We consider that it can serve of a special usefulness for analyzing and validating a specific experience of pervasive games in interactive spaces.

Items have been developed using different verification criteria, along the same lines as the recommendations for qualitative research that can be found in [56]:

--Making clear the basis of the researcher and establishing a connection with the literature, searching models (as the ones introduced in Section 3) that provide a base for the sense and propriety of what it is going to be observed.

--Judge triangulation: a minimum of four judges have taken part in the development of the items to be observed, as well as in the observation itself. This research work was of a special usefulness, not only for identifying the cases in which an expected event would occur, but, specially, for the analysis and further discussion about negative cases.

--Pattern identification and establishing: patterns have been connected with data and categories that emerged from the observation and that got confirmed because of their repetition during the different game experiences.

It should be noted that the choice of the elements to be observed was made by analyzing the potential of the game in a cross and exhaustive way, after a pilot experience, to discover which behaviors that were shown throughout the game were linked to the theoretical models on which this work is based [25], [36].

The tool also includes a section for field notes.

The observation tool is complemented with a group poster to be fulfilled with the players to assess each of the game missions (see Figure 11). In it, each child has to take a star-shaped sticker for each mission. Next to the name of the mission, a related image makes easier to remember which experience is being evaluated. In this evaluation, a three-ranged Likert scale underlies. For each level, a sticker with a different color is used. After each mission has been evaluated, the child is asked about why the evaluation chosen has been that one.

Fig. 11 Group poster for the evaluation of the game's missions (in Spanish).

VII. EVALUATING THE PERVASIVE EXPERIENCE

The Fantastic Journey has been assessed using the evaluation tools presented in last section. The goals of those evaluations were:

--To test the usefulness of the observation model aimed to observe and identify the proposed processes in the scope of a real game.

--To test the usefulness of the missions for developing the skills they were designed for, identifying the cognitive and socio-affective processes that the game activates in its players.

--To evaluate the satisfaction shown by participants when taking part in the experience.

TABLE XVII. OBSERVATION GRID FOR EVALUATING THE EDUCATIONAL ASPECTS

	DOES THE GAME ENCOURAGES THAT PARTICIPANTS…?	
	ATTENTION	
A1	Get focused on the sounds and images of the game.	A_FOC
A2	Continue to pay attention on the sounds and images of the game.	A_SOS
A3	Link hidden messages inside a text that is read or listened (e.g., a song) with the task to solve, paying attention to two different sources of information.	A_SOS & A_SEL
A4	Get focus on their position within the space relative to the position of the others.	A_FOC
A5	Pay attention to the totality of a scene and its parts, differentiating among all the possible locations of a challenge that has to be found.	A_SOS & A_SEL
A6	Pay attention to different instructions during the game, and integrate them.	A_SOS & A_SEL
A7	Pay attention to an image in a global way.	A_FOC
A8	Continue to pay attention to a proposal by the game and, at the same time, pay attention to information of an internal source (e.g., breathing).	A_SOS
A9	Get focused on a figure that stands out from a set of shapes, without giving up the attention on the whole of the image.	A_SOS & A_SEL
A10	Concentrate on an image.	A_SOS
A11	Inhibit external stimuli and concentrate on the internal experience.	A_SOS
A12	Reproduce aural and visual sequences.	A_SOS & A_SEL
A13	Continue to pay attention to an image at the same time that to an oral or written text that describes a situation to solve.	A_SOS & A_SEL
A14	Continue to pay attention to the movements that the different elements on a screen carry out and coordinate them with a button or mouse.	A_SOS & A_SEL
A15	Pay attention in a global way to an image in order to locate a given point in the space.	A_SOS & A_SEL
A16	Get focused on images and carry out a count of elements segmented by some criteria.	A_SOS & A_SEL
	PLANNING	
P1	Explain the steps being carried out in order to solve an individual or collective challenge.	P_MK
P2	Solve sequences of information coordinating aural information (e.g., from a song or instruction) with visual one (e.g., puzzles).	P_SC
P3	Modify their proposals according to conscience and self-evaluation during the solving process.	P_MK
P4	Coordinate and regulate their position in space in relation to others' position.	P_SC
P5	Analyze different options and take decisions regarding challenge resolution.	P_SC
P6	Solve the sequence of information proposed in the scope of a challenge.	P_SC
P7	Select and take decisions in order to find a piece of information integrated in a whole (e.g., word search puzzle).	P_SC
P8	Induce patterns that accomplish the rule in a series and execute them.	P_MK
P9	Select and take decisions to relate objects with their correct location.	P_SC
P10	Adjust their movement with the one of the objects that appear, looking for precision and speed.	P_MK
P11	Anticipate consequences in order to inhibit an impulsive behavior.	P_MK
P12	Keep calm as the key to solve a problem.	P_MK
	SOCIAL SKILLS	
H1	Respect and facilitate that everyone see and listen in group activities, not obstructing with their body or voice.	S_FOR
H2	Keep proximity with other members in the group.	S_FOR
H3	Make proposals for organizing the group dynamics.	S_FUN
H4	Mediate in group processes.	S_FUN
H5	Support the leadership when it is performed in a rotary way.	S_FUN
H6	Celebrate the resolution with other participants.	S_FOR
H7	Facilitate (encouraging or influencing) that everyone gets located in the space in a way that they get committed with solving the challenge.	S_FOR
H8	Enjoy the closeness of the other group members	S_FOR
H9	Get organized in groups spontaneously.	S_FOR

In the evaluations 30 children participated split into two sessions: the first one with 14 participants and the second one with 16. Children were between 7 and 11 years old. In each session, four groups of three or four participants were arranged. We tried that each group included different age ranges and genders. Data collecting was carried out during the process and after it finished. The structure of each session of the experience was:

--Reception of participants, presentation of participants and mediators and creation of teams (10 minutes).

--Playing *The Fantastic Journey* (50 minutes).

--Joint reflection about the experience (10/15 minutes).

For each session, the processes of attention, planning and social skills of each mission of the game were evaluated using the observation form of Table 18. Four observers-researchers (one for each group) registered how many children activated the cognitive processes and social skills that were required in each one of the missions that make up the game. After the game was finished, an evaluation about the degree of satisfaction of each participant in each mission was carried out using the group poster shown in Figure 11, complemented with a general game questionnaire.

A. Evaluation of processes and skills

With the goal of contrasting the usefulness of the missions for working on the processes and the skills they have been designed for, we have analyzed the behavior frequencies obtained by the four observers for each process type and each mission. Furthermore, non-systematized observations have been subsequently triangulated, obtaining different categories of analysis.

Results obtained with regard to the behavior observed in the process of attention, planning and social skills are detailed in Table 18. Figures in each square are the percentage of children in which a certain behavior related with that item was identified. The reference of each item by category can be found in the horizontal axis, and the ten missions that make up the game can be found in the vertical axis.

Results are shown as grouped by mission, and they include, together with the analysis of the systematic observation, those field observations collected by the observers, as they can add value to the analysis. Each mission incorporates its recommendations, which are compiled and categorized in Section 8.

1) Mission 1: Listening to Pipo's story

The beginning of the story by means of audio and video has allowed to observe the items about attention and social skills, in a way that everyone (Table 18) payed attention and continued paying it during the story and got involved in it, as all of them answered out loud, quietly or with mime to the questions made by Pipo. Furthermore, they started interacting among them in a nonverbal way and adjusted to the situation.

Recommendations: In this first phase it is very important, taking the observations into account, that the presentation itself makes questions to the children and get them involved from the very beginning. This is a key aspect, especially for continuing paying attention, as well as for establishing links and cooperation within the group.

TABLE XVIII. RESULTS OF THE OBSERVATION OF EACH OF THE OBSERVATION ITEMS (ROWS) FOR EACH MISSION (COLUMNS)

	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
A1	93,3									
A2	93,3									
A3		100								
A4			100							
A5				100						
A6				63,3						
A7					100					
A8					96,6					
A9					100					
A10					100					
A11					100					
A12						100				
A13							100			
A14								96,6		
A15									100	
A16									83,3	
	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
P1		73,3		63,3	96,6	86,6	26,6			
P2		96,6								
P3		83,3		66,6	86,6		33,3			
P4			100							
P5				63						
P6				60						
P7					86,6					
P8						100				
P9							46,6			
P10								80		
P11									56,6	
P12									60	
	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
H1	100								96,6	
H2	96,6									
H3		80		80		93,3	100	90		
H4		80		56,6			46,6	80		
H5		70		73,3	83,3	96,6	46,6	96,6		
H6		73,3		93,3		96,6	46,6	90		70
H7			100							
H8			86,6							
H9					100					
	95,8	82,1	96,7	72	95	95,5	55,8	89	79,3	70

2) Mission 2. Ordering the song and discovering the magic words.

The goals of this mission are to discover the magic words, paying pay attention to the lyrics of the song, and to organize the information in the puzzles. Although maintained and selective attention, as well as attention to two sources of

information, have been activated in all cases, planning processes show more mixed results, especially for the difficulty in the observation of metacognitive knowledge and explicit metacognition if a dialog is not established between the mediator and the participants. These items (P1 and P3) require that the child expresses it or of an intentional mediation by the mediator so that he/she can relate the process. This make difficult in some cases the possibility of observing this behavior in all participants at the same time. However, at least 70% of participants have made proposals for the development of group dynamics, have mediated in the process, have shared leadership and have celebrated the results obtained, even when leadership has not always been shared.

Recommendations: It is worth noting that in missions like this one, in which manipulation of tangible elements arise, a mediator should be present in order to make sure that the steps being carried out for the resolution of the tasks are being justified and that rotatory leadership is being facilitated. Indeed, these two aspects are the ones that have received lower scores.

3) Mission 3. Knowing about the story of the sun and the moon.

The goal of the mission is that the players make up together the shape of the sun and the moon. Attention (A4) and planning (P4) items got activated in all cases. It is worth noting that the skill of facilitating that everyone gets properly located was also shown in everyone (H1). However, in few cases they did not get to enjoy of the proximity with others (H8), as some children are very shy and do not contact with others.

Recommendations: the mediator's job in this mission is again a key aspect, in this case, for strengthening proximity among participants in order to solve the challenge, independently of children's personality.

4) Mission 4. Finding the suitcase and discovering the code.

In this mission, players first have to find a suitcase hidden in the interactive space. Afterwards, they have to solve four activities in the tangible tabletops that introduce computational concepts and provide the key to open the suitcase. In this mission, there was a notable difference between the two attention items: whereas all participants payed attention to totality and parts (A5), when the task requires the integration of several instructions, this is only observed in 63,3% participants.

The same as item A6, the ones related to planning (P1, P3, P5 and P6) show lower scores, as it is complex to activate metacognitive processes and they require the verbalization of the process in order to observe it. Observers noted down: "They verbalize out loud… and correct themselves if they detect a mistake", "they revise it before placing the planet".

The interest in solving the code of the lock has been detected in that they celebrated their advances in 93,3% cases (H6): "they get excited when getting the numbers". The missions have encouraged to make proposals (H3) and to support rotatory leaderships (H5): "good harmony and interaction in the group". Besides, only in 56,6% of the cases they have mediated in group processes: "the older child wants to dominate and solves soon, not letting the other participate".

Recommendations: In this case of a complex mission, it is important to keep an eye out for different paces so that everyone reaches the final resolution having made the full process. In this sense, if someone stands out for any reason (e.g., age), the mediator should be aware in order to direct this higher level of individual competence through the group.

5) Mission 5. Meditating and solving the word search puzzle.

After a meditation time to calm, a keyword has to be found in a word search puzzle displayed on the tabletops. The proposal has favored that attention items (A7, A8, A9, A10 and A11), as well as planning items (P1, P3 and P6) got activated in almost all participants, as it can be seen in Table 18.

It has also been observed how, in the same way that in Mission 4, the use of rotatory leadership (H5) is high (83,3%). Regarding spontaneous group organization (H9), observers say "They see it quickly. First, they have distributed the stones, and then they have placed them in a very organized way. Two of them go to the group at the right to see if they need some help. They are happy about how they are solving it… The group is united."

Recommendations: The presence of tangible elements to manipulate during the mission supposes a challenge and the mediator should be aware to it. Specifically, the mediator should facilitate that all participants take part. Rotatory leadership presents the lower score, which reinforces this idea.

6) Mission 6. Visiting the Sioux star.

Players have to hit the tabletops following a pattern that is shown in the wall projections. The proposal has facilitated maintained and selective attention in all children (A12). A good planning (P1 and P8) has been observed. They induced the patterns and executed them when carrying out the task (they made signs and verbalized them to supervise when using the drumstick). Also, they respected the order established and inhibited the impetus respecting others' turn.

Almost all participants (between 93.3 and 96.6%) made proposals for solving the task in an effective way (H3), shared the leadership (H5) and celebrated the resolution in group (H6): "happy with the resolution, very good reaction".

Recommendations: At this point of the game, after its midpoint, is when the mediator can check if advances are being produced, especially in what refers to social skills, and more specifically, about rotatory leadership, as this mission is another one with tangible elements. If this is the case, the result would be very positive. Otherwise, the mediator would have to change the strategy with the group.

7) Mission 7. Freeing the stars from the galactic web.

The goal is to free three stars that have been trapped in a spider web; players have to pair objects with the correct star by means of gestural interaction following the information previously displayed on the tabletops.

The challenge of the proposal -in the tangible table for collecting information and afterwards moving objects in the space- favored that everyone kept maintained and selective attention (A13). However, as the part of the mission that required to move objects was carried out in one group, only some children could take part while the rest of the group guided him/her. This made difficult the observation of the individual planning process (P1, P3 and P7), even when then the group did justify the steps, modifying proposals and taking decisions jointly: "they organized so that each one memorizes an object", "one of them goes over the objects to remember they later, reads and go to the screen, locating where they will later have to put each object", "they try to relate objects and stars, trying to highlight relevant information".

Regarding social skills, it is worth noting that all of them make proposals for later solving the mission (H3): "they help each other for making sure that all of them know where to locate the objects". However, for items H4, H5 and H6, as they are observed in a large group, scores are lower, although: "they participate actively helping others". Lastly, some of them do not like not being they who perform the mission: "they got frustrated for not taking part".

Recommendations: In this mission it is undeniable how difficult it is to observe as only one child for group is going to participate in the last part of the resolution. After seeing the results, this kind of missions in which the resolution in going to be in charge of one participants have to be re-thought. In the design of the mission, it is essential to find a way for getting everyone active all the time, thus avoiding lack of involvement and then frustration.

8) Mission 8. Destroying the meteorites.

Each group of players has to destroy the meteorites that appear on their tabletop by means of manipulating a physical space ship toy on the table.

The fact that the mission is similar to some well-known games and that they liked it facilitated that they maintained attention (A2) in 96,6% cases. Regarding planning, although in some cases precision has been a problem, in 80% cases the adjustment for getting precision and speed has been observed (P10).

With regards to social skills, work organization (H3), mediation (H4), leadership (H5), as well as achievement celebration (H6) have been satisfactory: "they enjoy with the game…, a girl gets frustrated in the last change…, there are no meteorites left".

Recommendations: Beginning from a mission they know and enjoy is a good starting point. The challenge in the mission is that, after rethinking its design, they keep finding it as a challenge, even when there exists the risk of being monotonous and not attractive due to its familiarity.

9) Mission 9. Discovering how many butterflies of each color appear.

Players have to stay quiet for a while so that butterflies projected in the wall stop moving and they can count how many of each color there are.

All participants have kept global attention on all butterflies (A15), whereas 83,3% have been able to focus and count all butterflies (A16). Besides, only 56,6% participants inhibited impulsive behavior as they taken into account the consequences (P11) and only 60% kept calm (P12): "a member of the group asked about which color counted each of them, so they distributed the colors", "they are aware and quiet counting the butterflies, but do not get organized regarding which color to count". Moreover, it is worth noting that almost everyone facilitated that in spontaneous movement throughout the space they did not complicated others' tasks (H1).

Recommendations: In this type of activities, in which behavior inhibition (not making noise) is key for the resolution, it is essential to stress this aspect with those participants for which this inhibition may be harder and would cause frustration in the group when not finishing the task. This type of activities that imply voluntary behavior inhibition may be adequate that get place near the end, as knowing about the participants' reactions can make easier for the mediator working on the aforementioned.

10) Mission 10. Dancing the song after finishing the game.

70% of the group danced to celebrate the end of the game, but the act of dancing is hard for some of them: "they gather together spontaneously", "some of them are reluctant to get seen dancing", "they do not exactly dance, but they show enthusiasm and clap hands with energy".

Recommendations: Celebrate achievements is a transversal element for all the game. Although this item is not noted as an observable element for all missions, the mediator should promote that it happens, as an element of self-recognition of the group. Nevertheless, this is the moment for the great celebration and the recommendation for the mediator is to be the first to get involved in celebrating with the group.

Regarding the utility of the observation model the very fact of having been able to observe the behaviors with a very high percentage of occurrences, as shown in Table 19, validates the relevance of most of the proposed items. Besides, the occurrence or not of these observed behaviors, is a source of recommendations for improvement for each mission, as it has just been commented. It is true that the observation grid could have been simplified, since it required, being so exhaustive, a triangulation of observations. However, a simplification would have brought less richness to the qualitative analysis of missions.

B. Satisfaction evaluation

A general players' experience measure was obtained using a reduced version of the Game Experience Questionnaire

(GEQ) [57]. This is a questionnaire aimed to evaluate diverse factors about the player's experience when playing games. This questionnaire includes various versions, including a concise version of 14 questions. As our players are children that may find hard to fulfill a long questionnaire, we reduced those questions to 7, one for each component that is measured: competence, sensory and imaginative immersion, flow, tension/annoyance, challenge, negative affect, and positive affect. Each question was answered with a value between 1 and 5. Also, we added an eighth question about the global feeling on the experience of playing. This way, the 30 players between 7 and 10 years that played the game answered to the questionnaire. Average values and standard deviations obtained can be found in Table 19.

TABLE XIX. RESULTS OF THE REDUCED VERSION OF THE GAME EXPERIENCE QUESTIONNAIRE

Component	Average value	Standard deviation
Competence	4,40	0,77
Sensory and imaginative immersion	4,50	0,82
Flow	4,07	1,41
Tension/annoyance	1,00	0,00
Challenge	3,10	1,47
Negative affect	1,33	0,80
Positive affect	4,80	0,55

From the descriptive analysis of the questionnaire, some interesting remarks can be made. The evaluation of most components is good, with values above 4 for almost all positive elements. Also, negative elements are valued with 1,33 and 1, which is the lowest possible value. In fact, all players gave a "1" to the question about annoyance when playing the game. Lastly, it is worth noting that there is a component difficult to interpret, as it is *challenge*. The values obtained here are varied, going from 1 to 5. The question was about the effort dedicated to the game, so it seems that there is a great difference in that sense. In a similar way, also the question about *flow* was given values in a range from 1 to 5, so it seems that the experience in that sense can be quite different from one child to another.

Besides, the panel in Figure 11 was used so that participants gave a score to the missions that make up the experience by using colored stars. Missions got valued one by one, and also spontaneous comments that justified the evaluation were collected. Those were, generally, quite positive, so observers noted comments such as: "funny, original and creative", "funny, entertaining, a challenge to solve" or "funny, in a group, I liked it very much".

Participants in both groups were observed smiling, happy, excited and very satisfied for having played. In both groups, the interaction that occurred within the group was well valued. Not surprisingly, collaboration seemed to be the most engaging element of the game for the children, as derived by their responses to the question about what they liked the most but also what they disliked the most -a good percentage of participants cited that they disliked it "when they could not cooperate/co-ordinate with the others".

Going into the detail of values in Table 20, it is interesting to see how children have mostly liked the game and has expressed that it has been very funny. In those missions that required to take turns for participating, which has been respected during the game, satisfaction has been a bit lower (missions M6 and M7).

TABLE XX
RESULTS OBTAINED IN THE EVALUATION PANEL

	I have liked it…		
MISSIONS	A lot	A bit	Not much
M1. Listening to Pipo's story	76,7%	23,3%	0%
M2. Ordering the song and discovering the magic words	83,3%	16,7%	0%
M3. Knowing about the story of the sun and the moon	70%	30%	0%
M4. Finding the suitcase and discovering the code	86,7%	10%	3,3%
M5. Calming and solving the word search puzzle	80%	20%	0%
M6. Visiting the Sioux star	86,7%	13,3%	0%
M7. Freeing the stars from the galactic web	70%	16,7%	13,3%
M8. Destroying the meteorites	80%	20%	0%
M9. Discovering how many butterflies of each color appear	40%	43,3%	16,7%
M10. Dancing the song after finishing the game	63,3%	13,3%	23,3%

It is interesting to see how a mission that is verbally valued as a difficult one can be valued a challenge that they liked or quite the opposite (e.g., missions M4 and M9). Some negative values are due to the few time to get adapted to the game dynamics or to technical problems such as the slowness in the response of the game (e.g., slowness of geo-locators used in mission M3).

It is also worth noting that mission M9 has been the worst valued, and it may require some changes in the feedback provided by the mediator or even in the instructions themselves. They proposed that each group focused on butterflies of just one color. It is also important that participants get intermediate and final feedback in this mission, and, in a technical point of view, it may be programmed again for making the butterflies move slower.

VIII. RECOMMENDATIONS

In this section we have compiled the recommendations that arise from the analysis of the results of the study, grouped and divided in two categories: design recommendations and mediation recommendations. For each one, its relationships with educational goals (Table 6) and mediation recommendations (Table 2) are indicated.

It is worth noting that, due to their nature, these recommendations are especially relevant for games in interactive spaces in which work is carried out with different stimuli and types of interaction in a physical game space shared by the children. However, these recommendations are

appropriate for any kind of game, as they introduce elements for reflection that go beyond the technology that supports this specific experience.

Design recommendations:

1) In the first phase of the game it is essential that the presentation talk to the children, ask them questions and get them implied from the first moment. This is especially important for maintaining attention, as well as for starting the generation of links and cooperation within the group (A_FOC, A_SOS, S_FOR, MR1 -Intentionality and reciprocity-).
2) Activities that require behavior inhibition (e.g., keeping quiet) should be placed near the end of the game, as the knowledge about participants' reactions can make the mediator's intervention easier in crucial cases (P_MK, MR4 -Feeling of competence-).
3) When the resolution is necessarily the responsibility of just one participant, the design of the activity must include a way in which everyone gets involved with the activity all the time, thus avoiding disconnection and further frustration (S_FOR and S_FUN, MR2 -Transcendence-, MR4 -Feeling of competence-).
4) To take as a starting point a well-known activity that the children enjoy when carrying it out can be initially motivating. The challenge in this kind of activities is thinking again about its design so that something that can become monotonous and few attractive is still seen as a challenge (A_SOS), MR2 -Transcendence-, MR4 -Feeling of competence-).

Mediation recommendations:

1) In those activities in which tangible elements are handled, it is essential that the mediator makes sure that participants justify the steps being followed for solving the task. It is also important that rotatory leadership is encouraged. (P_MK, P_SC, S_FOR and S_FUN, MR3 -Meaning-, MR6 -Sharing behavior-, MR8 -Planning-).
2) When the activity requires to solve a challenge with physical proximity among participants, the mediator's work is essential to encourage it, whatever the participants' personality characteristics are. (S_FOR, MR4 -Feeling of competence-).
3) When the activity includes complexity such as the one of programming, the mediator has to be aware for integrating the different paces so that everyone reaches the final resolution having followed of the planning processes that are needed. (P_MK, P_SC, MR4 -Feeling of competence-).
4) If anyone stands out, whatever the reason is (e.g., higher age), the mediator has to be aware so that this higher individual competence is channeled through the group (S_FUN, MR4 -Feeling of competence-).
5) When the half point has been passed, it is essential that the mediator checks if advances are being produced, especially in social skills, and above all in rotatory leadership. This sometimes will imply changing the strategy applied to the group (S_FUN, MR4 -Feeling of competence-).
6) Celebrating the achievements must be transverse to all the game. The mediator should encourage this to happen, so that the self-recognition of all the group is fostered. The recommendation is the mediator to be the first one to get implied in celebrating the achievements with the group (S_FOR, MR4 -Feeling of competence-).

IX. Conclusions And Future Work

This work starts from the hypothesis that pervasive games in interactive spaces have, due to their own features, a high educational potential. This potential is especially relevant in what refers to working attention, planning and social skills with children. However, this potential has been very rarely explored in the literature, so this work comes to fill in this gap.

We have presented a case study carried out with a population of children between 7 and 12 years old, in the scope of a pervasive game designed to be played in an interactive space that supports oral, gestural, corporal and tangible interaction. The missions that make up the game are examples of technological activities to work on cognitive and socio-affective processes that favor learning. In particular, attention, planning and social skills get favored.

We have also developed an observation grid oriented towards the identification of specific behavior that favor those processes and to evaluate whether the learning goals have been achieved. This grid, as every evaluation tool, can also be used to guide design process of specific activities that search the development of attention, planning and social skills.

Furthermore, from the experience of the case study we have pulled out some design and mediation recommendations that complement previous ones from the field of tangible interaction for the design of games in interactive spaces.

Putting all this together, this case study proposes a novel way to approach game analysis, from the point of view of making potentialities, limitations and lacks emerge so that they can guide the development of new games for interactive spaces that put together entertainment and educational value.

It is true that the development of such games is complex due to the scarce number of frameworks that facilitate those developments. But the interactive space allows to establish an interaction between the participants and with the play space itself that is difficult to replicate in other contexts and by other means. The potential of the manipulation of tangible objects, the facilitation through direct and face-to-face interaction with the mediators, the fact of sharing with other players "live" the diversity of spaces and universes that are recreated, makes the pervasive space an agent of learning of high potential.

Related to future work, more in-depth evaluations, also with children with attention deficits, are going to be made.

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