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Videogames: Multisensory Incentives Boosting Multiple Intelligences in Primary Education

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Abstract

Introduction. Our research focused on studying the extent to which the planned, systematic use of educational videogames can result in the generation of learning contexts conducive to developing Multiple Intelligences (MIs) amongst schoolchildren.

Methodology. A twofold methodological approach was adopted: a) *qualitative:* previous assessment and analysis of the videogame to be utilized in the experience, giving priority to its suitability and correspondence with primary education curricular areas; b) *experimental:* case study oriented to verifying the possible increase of MIs amongst pupils enrolled in the First Cycle of Primary Education (N=101) derived from implementing the videogame in the classroom during one academic year, using a control group and identifying the level reached before (test) and after the experience (post-test) with an assessment instrument.

Results. The previous selection of a videogame guarantees the acquisition and reinforcement of numerous learning formats linked to specific Primary Education curricular contents. The fun activities –related to all eight intelligences– imply motivating challenges for schoolchildren as well as chances to boost various skills. A widespread increase of all intelligences was observed after the playful-formative experience with the videogame; this became particularly significant in the cases of *logical-mathematical*, *visual-spatial* and *bodily-kinesthetic* intelligence –the first two improving to a greater extent in girls than in boys.

Conclusions: The starting hypothesis was verified: the introduction of suitable videogames in the classroom and their systematic exploitation promotes MI development amongst primary education children. In particular, measuring operations, mathematical calculations, counts, shape and size identification and classification, relationships and correspondences, etc., presented in an entertaining way by means of animations, graphics and drawings, together with the activities that promote body care (healthy diet and personal hygiene), facilitate learning and improve MIs.

Keywords: videogames, multiple intelligences, motivation, cognitive and emotional learning, skills.

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Videojuegos: Incentivos Multisensoriales Potenciadores de las Inteligencias Múltiples en Educación Primaria

Resumen

Introducción. La investigación se centró en estudiar en qué medida los videojuegos educativos, utilizándolos planificada y sistemáticamente, pueden constituir contextos de aprendizaje propicios para desarrollar las Inteligencias Múltiples (IM) en escolares.

Metodología. Se adoptó una dualidad metodológica: a) *cualitativa:* evaluación previa y análisis de contenido del videojuego a utilizar en la experiencia, primando su adecuación y correspondencia con las áreas curriculares de primaria; b) *experimental:* estudio de caso orientado a constatar el posible incremento de las IM en alumnos de Primer Ciclo de Educación Primaria (N=101) derivado de la implementación del videojuego en el aula durante un curso, utilizando un grupo de control e identificando el nivel alcanzado antes (*test*) y después de la experiencia (*postest*) con un instrumento de evaluación.

Resultados. La selección previa del videojuego garantiza la adquisición y refuerzo de numerosos aprendizajes vinculados con los contenidos curriculares de Primaria. Las actividades lúdicas -relacionadas con las ocho inteligencias- suponen retos motivadores para los escolares y ocasiones para potenciar diversas habilidades. Tras la experiencia lúdico-formativa con el videojuego se observó un incremento generalizado en todas las inteligencias, resultando significativas la *lógico-matemática*, la *viso-espacial* y la *corporal-cinestésica*, mejorando las dos primeras más en las niñas, que en los niños.

Conclusiones. Se verificó la hipótesis de partida: la introducción de videojuegos educativos adecuados en las aulas y su explotación sistemática promueve el desarrollo de las IM en escolares de primaria. Especialmente, las operaciones de medida, cálculos matemáticos, recuentos, identificación y clasificación de formas y tamaños, relaciones y correspondencias, junto a actividades que fomentan el cuidado del cuerpo (dieta saludable e higiene personal) presentados de forma lúdica facilitan el aprendizaje e incrementan las IM.

Palabras clave: videojuegos, inteligencias múltiples, motivación, aprendizaje cognitivo y afectivo, habilidades.

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Introduction

Depending on their purpose, videogames can be divided into commercial games (*Grand Theft Auto, Castlevania*, etc.), developed for mere entertainment, and educational ones, oriented towards learning (Connolly, Boyle, MacArthur, Hainey & Boyle, 2012). The latter include serious games, created with training aims for academic and scientific fields as well as for defense, health, conflict resolution, change promotion, etc. (Schollmeyer, 2006). They not only boost the development of multiple skills but also promote various types of learning (Lee, Heeter, Magerko & Medler, 2012) associated with health and socialization during childhood and teenage, (Pindado, 2005), amongst others. According to Wouters, van Nimwegen, van Oostendorp and van der Spek (2013), they can turn out to be effective educational tools –by favoring motivation and learning– (Adams & Clark, 2014) and become learning contexts in themselves, ideal to develop twenty-first-century skills (DiCerbo, 2014) such as collaboration, critical and creative thinking, problem solving, reasoning, learning to learn, decision-making, and digital literacy (Voogt & Pareja, 2010).

A number of experiences aimed at the integration of videogames into training contexts show that videogames help to acquire learning through the simulation of social processes and the encouragement for experimentation and curiosity (Cortés, García & Lacasa, 2012; Del Castillo, Herrero, García, Checa & Monjelat, 2012; Sung & Hwang, 2013). In turn, Robertson (2013) and Vos, van der Meijden and Denessen (2011) point out that –depending on their nature, themes and activities– they can optimize learning by giving players freedom of action. Annetta, Minogue, Holmes and Cheng (2009) along with Hickey, Ingram-Goble and Jameson (2009) state that they contribute to improve concept understanding, to acquire processing skills and to solve problems (Liu, Cheng & Huang, 2011); they favor the development of visual-spatial skills (Bailey & West, 2013) and boost emotional intelligence (Acampora, Loia & Vitiello, 2012; Herodotou, Kambouri & Winters, 2011).

Therefore, their educational potential is bound to make serious games become suitable catalysts for the development of Multiple Intelligences (MIs) –formulated by Gardner (2005) and defined as a multidimensional, diverse construct formed by the sum of eight types of intelligence: linguistic; musical; logical-mathematical; visual-spatial; bodily-kinesthetic; interpersonal; intrapersonal; and naturalistic. In other words, intelligence is conceived as a set of multiple capabilities which can be modified and increased (Antunes, 2005), improved by means of adequate stimuli and specific activities for each intelligence (Amstrong, 2009), relating them to different curricular areas (Fogarty & Stoehr, 2008; Prieto & Ballester, 2003; Prieto & Ferrándiz, 2001). More precisely, the experiences carried out by Saricaoglu and Arikan (2009) place the emphasis on MI increases in school contexts with the support of virtual environments (Riha & Robles-Piña, 2009), others with digital games (Sanford & Madill, 2007; Schaaf, 2012), and others utilizing videogames specifically linked to each intelligence, as it happens with the growth of logical-mathematical intelligence detected by Li, Ma and Ma (2012).

Thus, the fact that serious games are likely to become suitable stimuli to develop MIs because they contain multisensory components which privilege their success as suggestive learning contexts able to attract players' attention and favor their stay in the game makes it necessary to analyze how these serious games operate cognitively. The utilization of attractive narrative and technical resources increases users' engagement and ensures their immersion in the game. For Deater-Deckard (2013), engagement –or the subject's conscious predisposition to achieve certain aims– has to do with the positive emotions derived from perseverance and effort, essential to turn the videogame into an effective educational tool. Furthermore, the user fidelization process is affected by other factors that influence the adhesion or engagement of those users, such as social demands, emotional elements, and cognitive stages; (social, emotional, and intellectual) motivations; and the attributes of the game/genre (collaborative game play, demands and challenges) (Sherry, 2013), since they can increase the interest and expectations before the fun experience.

The relationship between *engagement* and motivation when it comes to keeping the player's interest is expressed by Garris, Ahlers and Driskell (2002) through a model which identifies the motivating aspects of videogames that make learning easier:

1. The game's dimensions associated with its instructional facet (fantasy, rules and goals, sensorial stimuli, challenge, mystery and control)
2. Decision-making by the player (interests, enjoyment, participation, task execution and confidence)
3. Player's behavior (sustained participation, effort, concentration, persistence and re-*engagement* to the game)
4. System feedback
5. The learning outcomes achieved (skills, cognitive and emotional learning)

In this respect, both the appealing narrative elements –fantasy worlds and creatures, mysterious places, magical resources, riddles and visual metaphors– that catch the player's attention and the interactivity which allows that player to make decisions based on certain rules or mechanisms to progress and reach the goals of the game; as well as the agile feed-back to reward or help him, etc., are key factors which contribute to the player's immersion or *flow* state. They help concentrate the player's attention on the activity, reducing his self-awareness and increasing his degree of control over the game (Esteban, Martínez, Huertas, Meseguer & Rodríguez, 2014). Nevertheless, the enjoyment and entertainment experience does not spare the player any efforts to complete the missions proposed successfully and to reach the maximum scores (Del Moral & Guzmán, 2014).

It is similarly worth highlighting that the esthetic, narrative and technical resources of videogames must favor the construction of optimum playful-educational scenarios for learning (Del Moral, 2004) which improve the *engagement* level from the existence of:

- A *story* which appears as the leitmotif of the action, where the script, the dialogues between characters and the setting increase the player's interest and immersion.
- *Levels with progressively growing difficulty*; the videogame must have a degree of difficulty which poses surmountable challenges in order to prevent the player from giving up and quitting (Islas, Leendertz, Vinni, Sutinen & Ellis, 2013).
- A suitable *game duration*, neither so excessively long as to become tedious and exasperating for the player nor too short to guarantee an extended enjoyment.
- *Sound and audio effects* which give credibility and verisimilitude to the action, along with dramatic effects that can involve the player emotionally.
- A *soundtrack* which reinforces the action as it happens in film narrations.
- *Dubbing*, in several languages, which not only makes learning the game easier but also extends its scope.
- A *graphic section* referred to image quality and sharpness, design (2D, 3D, etc.).
- *Videogame art* adapted to the characteristics of the target audience: rounded images for children, with artistic friendly designs and sweet characters.
- *Customization possibilities*, an aspect demanded by players, making the game's experience closer and more directly 'owned' by them. The creation of an *avatar* favors the user's representation and identity (Lin & Wang, 2014), and customization constitutes a rewarding task (Bailey, Wise & Bolls, 2009), insofar as players prefer to design their own avatar.

- An accurate *control over the movements* of characters –and their actions– so that playability can be improved.

After listing the multisensory components of videogames, it is important to determine the chances that they offer as a learning context when it comes to developing MIs.

Chances provided by videogames to develop MIs

Some videogames may become favorable environments to boost MIs; that requires knowing not only which game activities and mechanics activate each intelligence but also which skills they imply (Antunes, 2011), in addition to identifying the specific characteristics of each one (Prieto & Ballester, 2003; Prieto & Ferrándiz, 2001):

1) *Linguistic intelligence* or the ability to quickly process linguistic messages and to communicate. It can be activated with videogames involving skills related to description, narration, drawing-up of conclusions and summaries, conversations and all sorts of linguistic practices;

2) *Logical-mathematical intelligence* or the ability to carry out deductive reasoning (calculations, spatial geometry perception, measures, logic, quantities, sizes, distances, relationships between objects…). Its enhancement is possible with videogames that include mathematical puzzles, mental entertainment and calculation (game-training) (Chang, Wu, Weng & Sung, 2012). A special mention needs to be made of successful experiences with grown-ups (Basak, Boot, Voss & Kramer, 2008) and subjects with special educational needs (Papastergiou, 2009);

3) *Bodily-kinesthetic intelligence* or the ability to use the body in a skillful manner is favored by *exergaming* (*wiiU* and *XboxOne)*, simulating sports activities and improving motor skills (Graf, Pratt, Casey, Hester & Short, 2009);

4) *Visual-spatial intelligence* or the ability to distinguish shapes and objects, to recognize the environment, to transform, interpret and express received perceptions (recognition of maps, plans, orientation in virtual environments, etc.) can be developed with high-graphic-quality videogames, images and videos that require skills associated with spatial orientation and map interpretation, as well as the design and construction of puzzles and jigsaws (*The Sims* activate such skills through the construction of dwellings and neighborhoods on a plan). Greenfield (2009), Llorca (2009), Yang & Chen (2010) claim that some videogames enhance spatial skills, while Korallo, Foreman, Boyd-Davis, Moar and Coulson (2012) describe the positive cognitive effects linked to memory;

5) *Naturalistic intelligence* or the ability to understand nature, to classify living beings and to identify ecosystems is definitely strengthened with experimentation games such as *Norrath* (Castronova, 2006) or *Spore*, creating new species;

6) *Musical intelligence* or the ability to perceive, discriminate and express musical forms and sounds can be trained by means of videogames that include musical simulators or synthesizers to compose using different musical instruments, karaoke in the style of *Singstar*, and dancing games (*Step Mania* or *Dance Dance Revolution),* simultaneously activating bodily-kinesthetic intelligence. The soundtracks of some videogames played by prestigious symphonic orchestras promote the taste for music;

7) *Interpersonal intelligence* or the ability to perceive and understand other people. Its activation is possible through social simulation games. Educational applications supported on prosocial games succeed in helping risk players (Greitmeyer & Osswald, 2010), together with others which deal with ethical dilemmas and favor assertive relationships; and

8) *Intrapersonal intelligence* or the ability to gain self-esteem and to achieve self-motivation and a positive self-concept. A number of videogames –especially role playing games and social simulators– encourage personal improvement and professional development through decision-making, negotiation, mediation, etc.

An appropriate videogame selection will ensure the training of each intelligence as long as it envisages systematic activities that imply the interrelated use of all intelligences and promote collaboration-based learning formats (Echeverría, García-Campo, Nussbaum, Gil, Villalta, Améstica & Echeverría, 2011).

Aim

It basically consisted in identifying the extent to which the planned and systematic utilization of the videogame *Naraba World* can create a learning context suited for activating Multiple Intelligences amongst schoolchildren enrolled in the First Cycle of Primary Education.

Method

Participants

The sample included 6-to-7-year old pupils (N=101), with an experimental group (EG=81) and a control group (CG=20) –as can be seen in Table 1– whose MI level was measured at the beginning (Phase I) and at the end (Phase II) of the process, so as to check the evolution operated in the subjects' intelligences.

***Table 1.* Distribution of the sample (N = 101) according to the variables 'grade' and 'sex'**

Grade/Sex	Boys		Girls		Total
	Participants	C.G.	Participants	C.G.	
First Grade	20 (48.8%)	5 (50.0%)	17 (42.5%)	5 (50.0%)	47 (46.5%)
Second Grade	21 (51.2%)	5 (50.0%)	23 (57.5%)	5 (50.0%)	54 (53.4%)
Total	41 (50.6%)	10 (50.0%)	40 (49.4%)	10 (50.0%)	101 (100.0%)

Instruments

Grid for the analysis of the videogame's content

The esthetic, narrative and technical elements that define *Naraba World*, as well as its 40 missions, were thoroughly analyzed using the qualitative instrument developed by Del Moral (2004), after which each mission or task could be identified with the respective activated intelligence, the thematic area and the specific Principality of Asturias contents dealt with.

Questionnaire for Multiple Intelligence Assessment

The tool used to measure MIs, validated by Prieto and Ferrándiz (2001) and made up of eighty items –ten per intelligence– made it possible to identify the subjects' initial and final level in each one of the intelligences using a scale (1=very low; 2=low; 3=high; 4=very high), after which the subjects' individual progress could be monitored.

Procedure

Our research adopted a twofold methodological approach: a) *qualitative,* content analysis focused on the 40 missions contained in the videogame seeking to insert the latter within the classroom context, considering both the activities that it offers to activate the typical dimensions of each intelligence and the multisensory incentives that guarantee its playability; and b) *quantitative*, referring to the analysis about the experience carried out with the videogame *Naraba World* at the Gesta I School in Oviedo (Asturias).

After the examination of multisensory components and the assessment of this videogame's educational potential, the time came to systematize its integration into the classroom determining one hour a week for seven months, 25 sessions in all, to verify the boosted MIs. Figure 1 shows the research process as well as its stages.

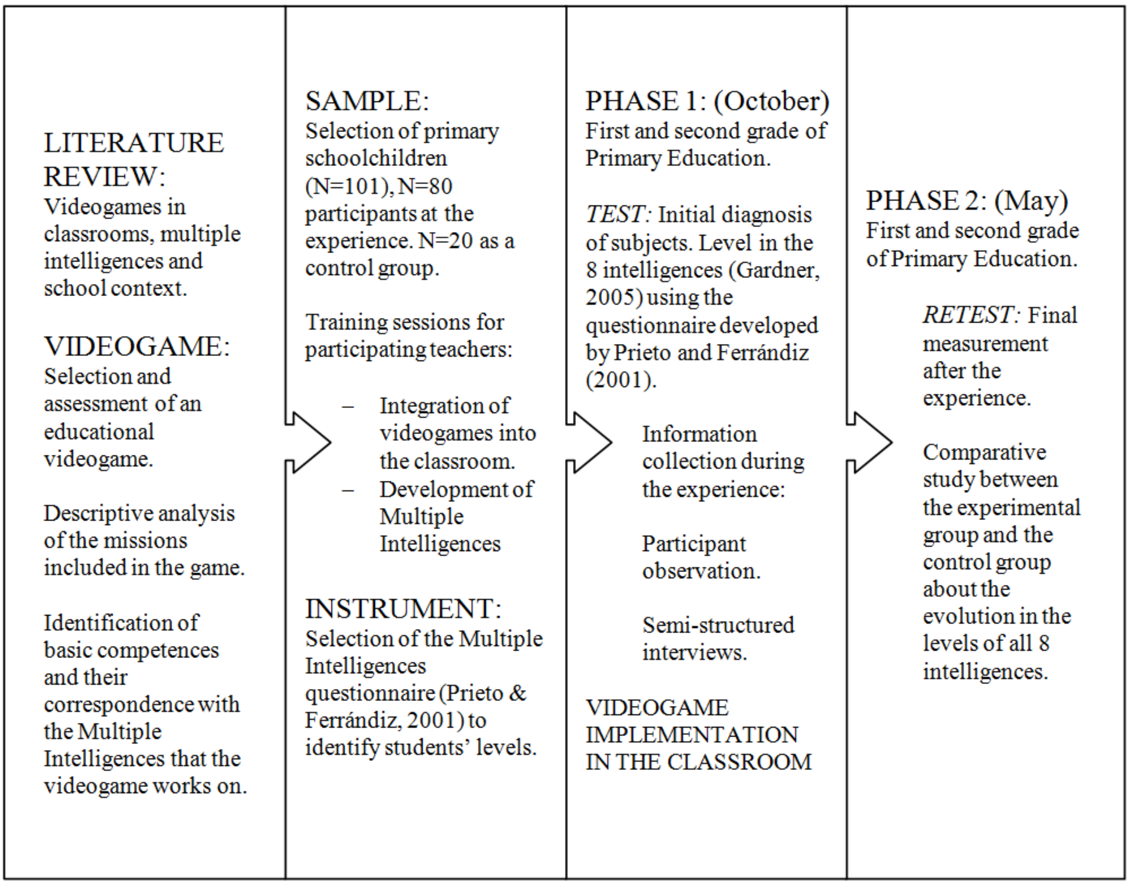

***Figure 1.* Game implementation process in the classroom**

The female tutors integrated the videogame into the 1st and 2nd grades of Primary Education relating its activities to the contents of three subjects –'Mathematics,' 'Knowledge of the Environment' and 'Music'– and to the MIs to which it was directly linked (logical-mathematical; naturalistic; and musical). Other curricular contents together with the remaining intelligences were transversally covered, for which purpose an *ad hoc* guide was drawn up that established a correspondence between each activity and the formative aims, the curricular contents and the types of intelligence. Furthermore, each student's level in all eight intelligences was registered when the experience began (Phase I: *Test*) and when it finished seven months later (Phase II: *Post-test*), using the questionnaire described above.

Design and data analysis

A descriptive multivariate data analysis served to verify the real contribution made by this videogame to MI growth. The statistical treatment (*Student's* t-test) compared both measurements (test/post-test) by means of a control group that allowed us to identify the existence of significant differences, this technique being advisable for small samples –since ours had a CG with only 20 subjects (Hair, Prentice, Cano & Suárez, 2007). The statistics were estimated at 95.0% liability, the statistical package SPSS v.18 being the choice made to perform our research work.

Results

Game content analysis: The videogame fulfilled several basic pre-requisites such as playfully covering curricular contents of the subjects 'Mathematics,' 'Knowledge of the Environment' and 'Music' –belonging to the First Cycle of Primary Education– and envisaging multisensory incentives (narrative, esthetic and technical resources) that involve and motivate the player.

Narrative resources: It is a third-person fantasy adventure which recreates colorful sceneries, forests, deserts, volcanos, etc., with invented creatures and magical characters and based on the travel metaphor, where players explore a variety of islands, moving on soap bubbles, balloons, etc., while they simultaneously solve different missions to move forward in the story.

Esthetic and technical resources: It has a suitable soundtrack, audio effects, high-quality dubbing, 3D animations. It allows the player to customize an *avatar*, selecting eye, hair and skin color, as well as clothing and accessories, with freedom to handle it –and to move it. All the missions have attractive graphics and drawings with an intuitive design that favors the player's immersion. The duration is appropriate, with the game incorporating several *difficulty levels* adapted to the knowledge owned at different ages. Each island provides a collection of missions with highly varied play mechanics that permit to overcome challenges and win an original pet as a prize –thus helping to achieve player loyalty– through the activation of MIs.

In total, it consists of forty missions to be performed by the player which are grouped together into three thematic areas: Knowledge of the environment (19); Mathematics (12); and Art education (9). Each one of them requires activating one or more intelligences in an interrelated fashion, resorting to strategies which boost the different intelligences to a greater or lesser extent (Gardner, 2005).

After assessing the game, it was observed that all missions required the simultaneous activation of several intelligences. Every mission needs *linguistic intelligence* when using oral and written texts in explanations and instructions, although the videogame did not use that type of intelligence explicitly because it did not cover curricular contents specific to the subject 'Spanish Language.' Nineteen of them are placed within the subject 'knowledge of the environment,' where seventeen boost *naturalistic intelligence* (Table 2) because they require skills associated with experimentation, observation and research, and dealing with topics such as health, recycling, respect for human beings and nature.

***Table 2* - Fun activities related to the 'knowledge of the environment' area**

Mission in the videogame	*Curricular contents*	*Intelligence that it develops*
Topic: Block 1. Environment and conservation		
Befish!: Dive to collect items, paying attention to the air available to breathe.	Importance of water for life. Exploration of water's physical characteristics through the senses.	Naturalistic, Visual-spatial and Bodily-kinesthetic Intelligence
Space Mission: Collect the highest possible number of stars in a certain period of time.	Perception and description of some elements and natural phenomena: the earth, the moon, stars and the sun, day and night.	
We travel in a balloon: Collect as many 'suns' as possible in the shortest possible time.		
We play with water: Perform changes of state in a given amount of water.	Importance of water for life. Exploring the physical characteristics of water through the senses.	Naturalistic Intelligence
Topic: Block 2. The diversity of living things		
Puzzanimal: Move a cube jigsaw until the image related to the display panel is obtained.	Making direct and indirect animals and plants (growth, characteristics and behavior) observation. Classification according to observable elements, identification and name.	Naturalistic and Bodily-kinesthetic Intelligence
Palm grove animals: Identify and select different animals.		
In the garden center: Take care of plants, cover their needs, and solve problems.	Relationships between humans, plants and animals. Food chains. Domestic and wild animals, wild and cultivated plants. Development of care habits and attitudes towards living beings.	
In the greenhouse: Take care of plants and cover their needs.		
We take care of the vegetable garden: Look after the garden and solve the arising problems.		
Producing to live: Form pairs, groups of three or combinations of four elements according to age range.	Relationships between humans, plants and animals. Food chains. Domestic and wild animals, wild and cultivated plants.	Naturalistic and Visual-spatial Intelligence
Topic: Block 3. Health and personal development		
Cleanliness and health: Form pairs, threesomes or foursomes according to age range, following a criterion of thematic logic, not of equality.	Identification and description of foods in a healthy diet. Knowledge about healthy eating habits. Assessment of personal hygiene and dress, appropriate postures, relaxation, and good use of free time.	Naturalistic and Visual-spatial Intelligence
That's what we are like inside: Complete a human skeleton as indicated in each case.	Identifying parts of the human body. Acceptance of one's own body and that of other people, with its limitations and possibilities.	Naturalistic and Visual-spatial Intelligence
We travel through the senses: Select one of the five senses and place it on the object with which it is related.		Naturalistic, Intrapersonal and Visual-spatial Intelligence
Tree circuit: Build a bridge, jump to avoid obstacles and collect rewards.	Acquisition of habits to prevent diseases and domestic accidents.	Bodily-kinesthetic Intelligence
Fruit cocktail: Make a cocktail with fruits gathered from the palm grove following a recipe.	Identification and description of daily foods needed for a healthy diet. Knowledge about healthy eating habits.	Naturalistic Intelligence
Block 4. People, cultures and social organization		
Ancestors: Complete a family tree.	The family. Relationships between its members. Balanced housework distribution and responsibility assumption.	Intrapersonal Intelligence
Help at home: Form pairs from certain elements and conditions.		

Block 6. Matter and energy		
We clean the world!: Collect and sort different types of waste in their containers.	The waste problem. Reduction, reuse and recycling of objects and substances.	Naturalistic Intelligence
Becristal!: Combine multiple equal elements for points.		

Twelve missions promote *logical-mathematical intelligence* through the utilization of numbers and operations, classifications, categorizations, measurement systems, comparisons, symmetry and geometry (Table 3).

***Table 3* – Fun activities related to the 'mathematics' area**

Mission in the game	*Curricular contents*	*Intelligence that it develops*
Block 1. Numbers and Operations		
Dancing crabs: Classify crabs by their type of movement.	Count, measurement, management and expression of quantities in everyday life situations.	Logical-mathematical Intelligence
Mischievous crabs: Sort crabs and put them in boxes.	Daily use of addition to put together or add; of subtraction to separate or remove; and of multiplication to calculate a number of times or as specific additions.	
Time to tidy up things!: Place elements in the correct position to complete sequences.		
Time for lunch!: Lay the table completing the spoons, forks and knives of all diners.	Count, measurement, management and expression of quantities in everyday situations. Reading and writing of natural numbers in words with their spelling.	
Miner's Apparel: Sort the typical elements of a miner in a closet.	Naming and determining the place value of numbers up to three digits using different didactic resources.	
Block 2. Measurement: magnitude estimate and calculation		
We fill the pantry: Weigh and balance products to store them in the pantry.	Direct or indirect comparison of objects by length, weight/mass or capacity.	Logical-mathematical and Visual-spatial Intelligence
Concoctions and potions: Mix colored liquids in containers of different sizes until obtaining the required amount of liquid of a certain color.	Measuring with unconventional instruments and techniques. Curiosity to know and apply daily-use measures and interest in the interpretation of messages containing information about measures.	Logical-mathematical Intelligence
Time measurement: Arrange a time sequence of images in a bar equivalent to one day.	Using time measuring units: cyclical time (day, week, month, year); and time intervals (clock reading, hours, half-hours).	Logical-mathematical and Naturalistic Intelligence
Block 3: Geometry		
Light the mine: Guide light through the mine using mirrors until you have lit it completely.	Use of geometric vocabulary to describe itineraries: open and closed lines; straight lines and curves.	Logical-mathematical Intelligence
Goldfish: Help the aquarium caregiver feed the fish.	Identification and classification of flat figures in common objects and spaces according to their appearance or size. Identification and description of geometric bodies in ordinary objects, using basic geometric vocabulary. Comparison and classification of flat solid figures with elementary criteria. Search for regularity elements in figures and bodies based on object manipulation.	Logical-mathematical and Visual-spatial Intelligence
Figures and shapes: Organize a jigsaw puzzle made up of rotating cubes that spin when you 'click' on them, until you form the image suggested on the panel.	Curiosity and interest in the identification of shapes and their characteristic features. Confidence in one's own possibilities, curiosity, interest and perseverance in the search for solutions.	Logical-mathematical and Visual-spatial Intelligence

Block 4: Information Processing, chance and probability		
We interpret what we see: Classify several items according to a variety of criteria.	Verbal description, achievement of qualitative information and interpretation of significant elements from simple graphs related to phenomena occurring in our immediate environment.	Logical-mathematical and Visual-spatial Intelligence

Nine missions are placed within the subject 'art education' favoring *musical intelligence* through the training of auditory perception, sound discrimination, musical production, composition and performance, together with rhythm memorization and repetition (Table 4).

Table 4 **- Fun activities related to the 'Art Education' area**

Mission in the game	*Curricular contents*	*Intelligence that it develops*
Block 4. Musical Performance		
Dance of the different islands: Aquana, Alba, Areliosa, Grana, Bruna y Feralis: Play the distinctive tune of an island with its typical instrument.	Playful exploration of the sound and expressive possibilities of voice, body and objects. Performance and memorization of rhythmic reciting and songs in unison.	Musical Intelligence
Shall we repeat?: Play the musical sequence that the player listens to.		
We work with rhythm: Play the rhythm suggested by a character.	Performance and memorization of rhythm reciting and songs in unison.	Musical Intelligence
Virtuous Jellyfish: Group jellyfish according to the sound that they make and take them to the corresponding pond.	Playful exploration of the sound and expressive possibilities of voice, body and objects. Performance and memorization of rhythm reciting and songs in unison.	Musical and Visual-spatial Intelligence

Other intelligences are complementarily developed, such as *visual-spatial intelligence* with an enhancement of visual perception, art production and appreciation, and *bodily-kinesthetic intelligence* by training fine motor skills through the use of keyboard and mouse to operate interactive elements. *Intrapersonal intelligence* is promoted by resorting to self-control and self-discipline, and favoring the consolidation of a self-concept. Finally, other missions build a connection with *intrapersonal intelligence* through interaction with others and conflict resolution, as well as through the assumption and knowledge of the different social roles and leadership skills.

Therefore, the previous thorough study of our serious game highlighted the correspondence between the missions proposed and Primary Education contents, together with the intelligences explicitly or implicitly boosted by those missions, which helped to consider this game suitable for research. Figure 2 shows examples of missions linked to various curricular areas and related intelligences in the game.

Figure 2. **Examples of missions in the *Naraba World* video game and their connection with MIs**

Results obtained through the MI Questionnaire

The assessment of the eight aforelisted intelligences –utilizing the 10 indicators developed by Prieto and Ferrándiz (2001) for each one of them, and establishing 4 levels (1=very low; 2=low; 3=high; 4=very high)– reveals the schoolchildren's achievements in each intelligence during both phases. Table 5 shows the subjects' distribution in percentage terms according to their level, where the comments of the experimental group (EG) highlight a widespread growth, reduce those corresponding to *very low* and *low* levels, provoking an upward movement towards *high* and *very high* levels –*visual-spatial intelligence* (21.7%) and *interpersonal intelligence* (19.6%) particularly stand out in this regard.

Table 5. **Percentage distribution by level of each intelligence (EG)**

Intelligence	% Phase I				% Phase II			
	Very low	Low	High	Very high	Very low	Low	High	Very high
Linguistic	6.7	35.7	48.4	9.3	5.2	28.6	51.1	16.7
Naturalistic	12.1	34.6	45.4	7.9	8.2	22.1	52.8	17.7
Logical-mathematical	10.8	37.4	46.3	4.8	6.4	27.8	48.2	17.7
Visual-spatial	7.4	33.0	54.2	6.2	4.0	23.6	51.1	21.7
Musical	7.1	33.8	52.2	7.4	3.4	25.9	55.1	15.3
Bodily-kinesthetic	8.0	37.8	47.0	7.0	5.1	27.2	49.4	18.4
Interpersonal	10.7	28.6	50.7	9.9	6.7	20.1	54.3	19.6
Intrapersonal	5.9	35.5	52.1	6.4	3.7	27.4	56.3	12.2

The comparison of means between both phases makes it clear that all intelligences improve with this videogame (Table 6 and Figure 3), especially so in the cases of: *visual-spatial intelligence* (Mean=2.91, SD=0.59), *interpersonal intelligence* (Mean=2.86, SD=0.79) and *linguistic intelligence* (Mean=2.86, SD=0.55), pushing them up to 'high' and 'very high' levels. However, this only happens to a significant extent with *logical-mathematical intelligence, visual-spatial intelligence* and *bodily-Kinesthetic intelligence*.

***Table 6*.** **Mean scores achieved in each intelligence**

Intelligence	Initial phase		Final phase	
	Mean	Standard deviation	Mean	Standard deviation
Linguistic	2.60	0.56	2.86	0.55
Naturalistic	2.49	0.65	2.80	0.66
Logical-mathematical	2.46	0.57	2.74	0.66
Visual-spatial	2.59	0.50	2.91	0.59
Musical	2.60	0.52	2.82	0.53
Bodily-kinesthetic	2.53	0.74	2.81	0.79
Interpersonal	2.60	0.81	2.86	0.79
Intrapersonal	2.59	0.70	2.77	0.71

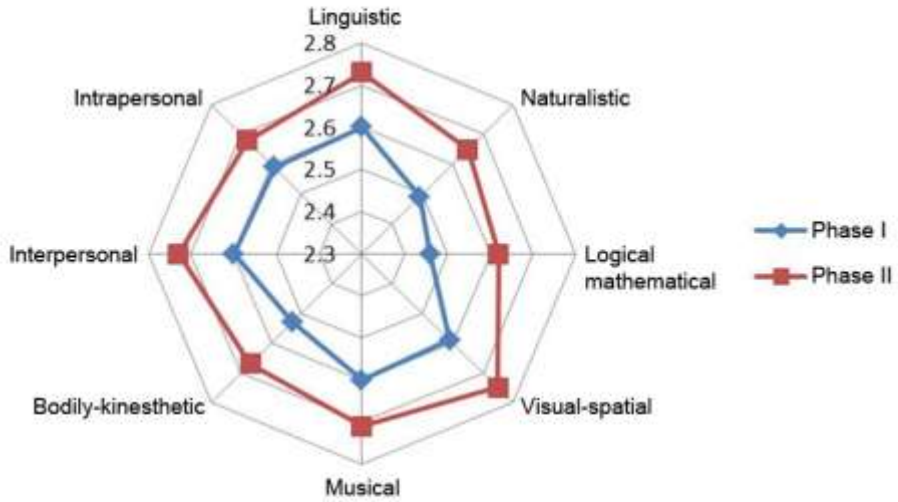

Figure 3. **Comparison of the mean scores achieved in both phases**

Although Student's t-test detects a tendency towards the improvement of intelligences influenced by this videogame, no significant differences exist between the EG and the CG (p<.05) with regard to the grade, even though there is indeed a difference according to the sex variable, but only for *visual-spatial intelligence* (p<.039) and *logical-mathematical intelligence* (p<.003), which improve to a greater extent amongst girls than amongst boys. The other intelligences do not show any relevant outcomes, insofar as their *p value* suggests a total absence of differences across groups.

A more in-depth analysis of the indicators that shape each intelligence enables us to see that, even though they all improve in qualitative terms, the comparison of means reveals that the increase only reaches significant proportions in *logical-mathematical intelligence, visual-spatial intelligence* and *bodily-kinesthetic* intelligence –this does not happen in *musical intelligence* and *intrapersonal intelligence*. Hence our decision to present only those tables which contain the distribution of subjects in percentage terms according to the level reached in the indicators that contribute to explain each one of the intelligences which were significantly improved at the end of the experience, thus stressing the positive influence exerted by this videogame upon MI development.

In *Phase II,* a significant improvement of *logical-mathematical intelligence* can be checked (Table 7) in the indicators related to *mental calculations, taste for mathematical* *missions* (*p*<.029), *jigsaws (p*<.001), *logical sequences and strategies* (*p*<.033), *category establishment* (*p*<.014), *abstract thinking* (*p*<.023), and *cause-effect relationship* (*p*<.018).

Table 7.* Percentage distribution of subjects according to the level reached in *Logical-mathematical intelligence

Items of each Intelligence	Phase I				Phase II			
	Very low	Low	High	Very high	Very low	Low	High	Very high
1. They ask many questions about how things work.	9.9	33.3	48.1	8.6	7.4	21.0	51.9	19.8
2. They make quick mental calculations to solve arithmetic problems in the videogame.	12.3	38.3	43.2	6.2	6.2	24.7	49.4	19.8
3. They enjoy mathematics classes.	4.9	38.3	49.4	7.4	3.7	27.2	49.4	19.8
4. They find the videogame's mathematical missions interesting.	7.4	35.8	46.9	9.9	3.7	22.2	46.9	27.2
5. They like to play games that require using strategies.	6.2	34.6	53.1	6.2	4.9	16.0	58.0	21.0
6. They like to do jigsaw puzzles.	3.7	32.1	63.0	1.2	3.7	16.0	63.0	17.3
7. They like to organize things through the establishment of hierarchies or categories.	12.3	34.6	50.6	2.5	6.2	27.2	51.9	14.8
8. They like to simulate experiments, and they do so showing that they can handle cognitive processes which involve higher-level thinking.	12.3	50.6	35.8	1.2	6.2	46.9	38.3	8.6
9. Their level of thinking is more abstract than that of their peers/classmates of the same age.	21.0	42.0	34.6	2.5	12.3	44.4	30.9	12.3
10. They have a good understanding of cause and effect for their age.	17.3	34.6	44.4	3.7	9.9	32.1	42.0	16.0

As for *Visual-spatial intelligence* (Table 8) (Phase II), an increase occurs in the scores corresponding to *perception and production of mental images or images on the screen* (*p*<.002)*, the visual aspect prevails* (*p*<.000)*, they create puzzles and mazes* (*p*<.024)*, they enjoy drawing (p*<.004)*, they like to activate animations (p*<.021)*, they handle the videogame* (*p*<.021)*,* and*, they easily decipher and elaborate graphs and diagrams* (*p*<.006).

Table 8.* Percentage distribution of subjects according to the level reached in *Visual-spatial intelligence

Items of each Intelligence	Phase I				Phase II			
	Very low	Low		Very low	Low		Very low	Low
1. They perceive and produce mental images, think by means of drawings and visualize the simplest details.	8.6	37.0	51.9	2.5	3.7	21.0	54.3	21.0
2. They pay more attention to images seen on the screen than to written texts.	2.5	12.3	74.1	11.1	1.2	4.9	56.8	37.0
3. They are imaginative. They do not see things in the same way as their peers/classmates.	11.1	44.4	35.8	8.6	4.9	37.0	39.5	18.5
4. They enjoy artistic activities.	2.5	30.9	61.7	4.9	2.5	22.2	60.5	14.8
5. They can mentally change the shape of an object and carry that out in practice (edit the avatar).	8.6	44.4	44.4	2.5	2.5	29.6	48.1	19.8
6. They enjoy watching the videogame's animations and visual representations.	0.0	17.3	75.3	7.4	0.0	7.4	59.3	33.3
7. They create representations of the specific or visual information (puzzles and mazes in the videogame).	8.6	43.2	46.9	1.2	4.9	32.1	51.9	11.1
8. They take an interest and are skillful at tasks that require visual-spatial skills (game management).	8.6	33.3	48.1	9.9	6.2	24.7	43.2	25.9
9. They find it easy to decipher and draw maps, schemes, diagrams, graphs and charts.	11.1	42.0	40.7	6.2	6.2	38.3	33.3	22.2
10. They like to draw in the videogame's drawing workshop; and they also like to color, to make collages ...	4.9	24.7	63.0	7.4	3.7	18.5	64.2	13.6

The significant increases in *bodily-kinesthetic intelligence* at the end of the experience (Table 9) are detected in indicators associated with *manipulation and motor accuracy* (p<.008), *movement simulation with the avatar* (p<.001), and *expression of physical sensations* (p<.006), the most visible increases appearing on 'high' and 'very high' levels: 70.3%, 77.8%, and 79.0% respectively. No relevant increases are identified in the other *items*.

Table 9. **Percentage distribution of subjects according to the level reached in *Bodily-kinesthetic intelligence***

Items of each Intelligence	Phase I				Phase II			
	Very low	Low		Very low	Low		Very low	Low
1. They excel at sports.	7.4	44.4	33.3	14.8	3.7	42.0	30.9	23.5
2. They move rhythmically and manipulate objects when they have to sit in the same place for too long.	7.4	35.8	46.9	9.9	3.7	32.1	43.2	21.0
3. They intelligently mimic other people's gestures and manners.	13.6	32.1	49.4	4.9	9.9	30.9	50.6	8.6
4. They love to take things apart and then to put them back together.	12.3	44.4	38.3	4.9	8.6	38.3	42.0	11.1
5. They like to manipulate things (as far as the videogame is concerned, to use mouse and keyboard).	7.4	35.8	46.9	9.9	4.9	23.5	42.0	29.6
6. They like to run, to jump in reality, and to simulate the same behavior with their avatar.	8.6	27.2	59.3	4.9	0.0	17.3	51.9	25.9
7. They show skill and motor accuracy with computer peripherals.	6.2	42.0	39.5	12.3	4.9	24.7	40.7	29.6
8. They express themselves using gestures to say what they mean/think.	6.2	40.7	50.6	2.5	3.7	17.3	70.4	8.6
9. They express different physical sensations while working with the videogame.	6.2	46.9	45.6	1.2	3.7	27.2	53.1	16.0
10. They like manual activities.	4.9	28.4	61.7	4.9	2.5	18.5	69.1	9.9

The indicators related to *writing, reading, cause-effect skills, enjoyment of narrations* and *simulations in the videogame, good memory* and *oral communication* are the ones which contribute to enhance *Linguistic intelligence*. Nevertheless, significant increases were only found in *taste for rhymes, tongue-twisters…* (p<.042), and they cannot be attributed to the videogame because the latter does not contain any missions about such issues.

Naturalistic intelligence has some improvement in the indicators linked to *videogame enjoyment, curiosity, simulation, comparison and classification*, but only to a significant extent in the indicator associated with *owning a large amount of knowledge about topics related to Science* (p<.032).

The indicators linked to *empathetic capacity* and *they help others/help to others* increased to a significant extent in *interpersonal intelligence* (p<.007).

In the case of *musical intelligence*, despite the improvement in the indicators related to *memory of melodies*, *skill to compose* and *taste for music*, and although the videogame contains missions associated with *music* and *its rhythmic way of speaking or moving,* as well as *the recognition of pitch in music*, the increase does not turn out to be statistically significant.

Intrapersonal intelligence reveals increases in indicators such as *being aware of one's emotions, working autonomously, having one's objectives clear,* and *taste for working on an individual basis* but they are not significant either.

Discussion and conclusions

The videogame selected can be described as a valuable catalyst to boost MI development amongst schoolchildren enrolled in Primary Education, the implementation of which in the classroom required a previous thorough study to extend its efficiency. This paper finds a coincidence with the results obtained in similar research works where the use of videogames is related to an effective development of Multiple Intelligences (Chuang & Su, 2012; Li, Ma & Ma, 2012).

The experience focused on the school integration of videogames carried out here made it clear that these games can definitely become learning contexts in themselves and favor the development of Multiple Intelligences, provided that they fulfill a number of educational requirements such as: dealing with curricular contents and favoring skill training as well as competence development –in addition to exploiting their fun potential and orienting their multisensory incentives at the service of learning. The previous selection of a videogame becomes crucial for that purpose: analyzing the content of the missions or activities included in it; assessing its adaptation to primary education curricular contents, as well as the identification of the chances that the videogame offers to boost MIs. Moreover, from the fun point of view, the videogame's multisensory components (narrative, esthetic and technical resources) should encourage students to become involved in the story proposed and ensure their empathy by means of incentives favoring their wishes to succeed and have fun (Ritterfeld, Cody & Vorderer, 2009).

More precisely, the videogame *Naraba World*, made up of missions closely linked to primary education curricular areas, facilitated the acquisition and training of a wide range of capabilities and skills, especially promoted the activation of *logical-mathematical intelligence* from games that include counts, measurements, quantities, series, logical sequences, equivalences, sizes, shapes, etc.; of *naturalistic intelligence* through the description of human body parts, the promotion of healthy eating habits, experimentation, nature observation, study of animal and vegetal living forms, etc.; of *musical and visual-spatial intelligence* by means of rhythms, melody reciting, organization of shapes in space, playful exploration of the sound and expressive possibilities of voice, body and objects, etc. *linguistic intelligence* was implicitly enhanced with all missions because it requires understanding various languages (oral, visual, textual, graphic, multimedia, etc.), even though no specific activities were available to work explicitly with that type of intelligence. Numerous missions simultaneously activated several intelligences in a coordinated way giving priority to some of those intelligences rather than to others.

The implementation of our videogame in the classroom made it possible to assess the increase of the aforelisted eight intelligences operated in schoolboys and schoolgirls after taking part in the experience. A widespread increase was identified in all of them, but especially so in *logical-mathematical intelligence* due to the typology of activities which favor its training to a greater extent, since plenty of missions promote categorization, sequencing, mental calculations and jigsaws. Similarly, *visual-spatial* and *bodily-kinesthetic intelligence* obtained optimum results because of this videogame's format –and the execution of some missions requires visual discrimination skills (object shapes and sizes), activating animations, graphics and drawings. Playfully describing activities which promote body care (healthy diet and personal hygiene) makes learning easier. To this must be added that the use of peripherals to move objects across the screen needs precision and a suitable motor manipulation to simulate movements in the game, which undoubtedly contributes to the player's training.

Likewise, and even though the videogame did not propose specific missions oriented to activating *interpersonal intelligence*, a significant increase was observed in the indicators referring to the development of an empathetic capacity and the encouragement of help to others. This was shown by the fact that children helped each other in the classroom during the game, particularly in the most complicated missions, thus generating a highly enriching collaborative game play atmosphere, minimizing even disruptive behaviors and causing an exchange of roles because it turned out that the students who were the best experts in this videogame also stood out for being the most absent-minded in conventional classes. In fact, they felt more recognized by their classmates –and also less skillful players– when they gave those classmates support in the resolution of problems posed by the game.

Furthermore, it could be checked that girls benefited to a greater extent than boys from the videogame-based experience, insofar as they significantly improved their levels of *visual-spatial* and *logical-mathematical intelligence*. The measuring operations, mathematical calculations, counts, shape and size identification and classification, relationships and correspondences, etc., presented in an entertaining way by means of animations, graphics and drawings, together with the activities that promote body care (healthy diet and personal hygiene) facilitate learning and improve MIs.

It is worth highlighting that turning the videogame into a catalyst that can activate MIs in primary education schoolchildren was only possible through a rigorous selection and a previous content analysis, both from the fun perspective, assessing the quality of the narrative, esthetic and technical resources used by the videogame, and in educational terms, examining the missions or activities suggested by the videogame with the aim of adapting it to the curriculum, taking the didactic and organizational measures needed to guarantee its efficient implementation in the classroom.

It can finally be concluded that educational videogames have the potential to contribute to success in numerous learning formats on the basis of the missions proposed in those games, simultaneously activating all intelligences. Without a doubt, this poses a new challenge for teachers, insofar as they must learn to exploit the potential of these tools typical of leisure contexts with which students are increasingly familiar so that they can become didactic tools at the service of learning.

For the future, it seems necessary to increase sample size, and also to make experiments with other more complex serious games. The videogame selected did not include specific activities to work on the subject 'Spanish language' and that made it impossible to verify the increase of *linguistic intelligence* because this area was not explicitly covered –it was covered implicitly, though, because missions were presented in writing and their statements had to be understood. The experience could additionally be replicated in the healthcare context or in non-formal educational scenarios as a way to stress the potential of videogames as MI catalysts once again.

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