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ORIGINAL

Game-Based Learning: Increasing the Logical-Mathematical, Naturalistic, and Linguistic Learning Levels of Primary School Students

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ABSTRACT

Game-based learning is an innovative methodology that takes advantage of the educational potential offered by videogames in general and serious games in particular to boost training processes, thus making it easier for users to achieve motivated learning. The present paper focuses on the description of the Game to Learn Project, which has as its aim not only to promote the use of serious games and digital mini-games for the development of Multiple Intelligences, but also to analyse whether this methodology results in increased learning. Teachers assessed the level achieved by primary education students (N=119) in each learning category, before and after participating in the project, by means of a qualitative instrument. Finally, after corresponding analysis through descriptive statistical techniques, bivariate correlations, and ANOVA, the results showed significant differences between children's learning levels in logical-mathematical, naturalistic and linguistic abilities before and after their participation in this innovative project, thus revealing a widespread increase in every indicator.

KEYWORDS: GAME-BASED LEARNING, LOGICAL-MATHEMATICAL INTELLIGENCE, NATURALISTIC INTELLIGENCE, LINGUISTIC INTELLIGENCE, DIGITAL GAMES

1 INTRODUCTION

The use of video games as a learning tool at school has grown in recent years (Ke, 2009). This has created a sort of parallel school (De Aguilera & Méndiz, 2003) driving a new trend where users become designers of their own Game-Based Learning environments (Squire, Giovanetto, Devane, & Durga, 2005). Numerous pieces of research highlights successful educational outcomes derived from innovative education mediated by video games. Robertson and Miller (2007) analysed the positive impact of innovative video game practices on the reasoning skills of preschool students. Mouws and Bleumers (2015) highlighted the increasingly favourable attitude of primary education students towards the learning of geography linked to the playful scenario that these authors recreated for learning contextualization purposes.

In turn, Lester et al. (2014) emphasized the significant increase in student achievement in math and science when using video games. Squire and Jan (2007) showed how certain video games can contribute to activating skills related to scientific argumentation and solving scientific problems. The experience developed by Papastergiou (2009) with digital games in secondary education underlines their potential as catalysts for learning and motivation. Similarly, Filsecker and Hickey (2014) highlights the extent to which videogames increase students' degree of involvement in their tasks. Within the university context, Whitton (2007) considers that videogames can generate experiential and immersive –as well as attractive– problem-based learning types.

The adoption of a methodology that revolves exclusively around using digital games, serious games or videogames –Game-Based Learning– appears as a disruptive educational practice which takes advantage of the intrinsic motivating effect that specific videogames have in terms of capturing learners' attention. Game mechanics and dynamics help to immerse students in appealing tasks, which facilitate learning through a reduction in the level of difficulty (Sørensen & Meyer, 2007; Turkay, Hoffman, Kinzer, Chantes, & Vicari, 2014).

Different researchers (Hamari et al., 2016; Ke, 2014; Wouters & van Oostendorp, 2013) assert that this innovative methodology will most probably give a boost to training processes, making it easier for students to acquire learning in a motivating manner. On an international level, experiences based on this methodology have been developed in school contexts, using serious games or digital games with the aim of promoting the development and acquisition of basic skills and competences (Riemer & Schrader, 2015).

Along the same lines, the present chapter examines a research experience performed in the Spanish context which describes and assesses the Game to Learn Project, using the Game-Based Learn-

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ing methodology to promote the use of serious games and digital games to favour the development of Multiple Intelligences (MIs) (Gardner, 2012) amongst primary education schoolchildren, and more precisely, of logical-mathematical, naturalistic and linguistic intelligences.

2 GBL: DEVELOPMENT OF LOGICAL-MATEMATHICAL, NATURALISTIC, AND LINGUISTIC INTELLIGENCES IN PRIMARY EDUCATION

Play undoubtedly constitutes an ideal scenario for schoolchildren to acquire learning in a wide variety of ways; to quote but two examples, some games help in language structuring (Torres, 2015) while others favour the development of thinking, thus making it possible to achieve significant learning outcomes (Glenberg & Robertson, 1999; Schechter, Macaruso, Kazzakoff, & Brooke, 2015). The progressive transfer of fun scenarios to videogame screens has resulted in new educational opportunities (Prensky, 2007), giving rise to didactic strategies focused on the utilization of videogames in classrooms. However, this methodology known as Game-Based Learning arises as an innovative practice which exploits the educational potential that videogames, serious games or digital games hold to drive any training process, thus favouring motivation-assisted learning acquisition by users, helping to involve them and assigning them a more active role (Téllez & Iturriaga, 2014). Videogames are systematically used as skill-activation and knowledge-acquisition tools within this educational framework (Liu, Rosenblum, Horton, & Kang, 2014).

This GBL methodology obviously rescues the social component of play when fostering social skills as well as cultural and social values (Gros, 2000), in addition to developing critical thinking. Without a doubt, the interaction with a videogame allows the player to control both its characters and the simulated situations, while he becomes immersed in a virtual world that resembles the real one. Nevertheless, a previous selection of suitable videogames or serious games designed for the educational purpose sought becomes essential to achieve effectiveness and to make the most of the play potential. Such virtual worlds activate problem-solving strategies other than those used in conventional education (Graesser, 2017), offering creative formulas to undertake new challenges such as multiple intelligence development.

3 VIDEOGAMES AND THE DEVELOPMENT OF LOGICAL-MATHEMATICAL INTELLIGENCE

Logical-mathematical intelligence is the capability associated with subjects/students' logical and mathematical organization processes, as well as with their scientific skills, especially linked to visual-spatial intelligence (Antunes, 2011). Applying the Theory of Multiple Intelligences (Gardner, 2012), supported by the GBL methodology at school, makes it possible to integrate videogames into the school curriculum with a view to boosting the different intelligences in an interrelated way (Sánchez, Álvarez, Dávila, & Mellado, 2017; Alfageme & Sánchez, 2002), since such digital games combine visual and spatial aspects with interactive elements.

Therefore, work on logical-mathematical intelligence necessarily must be based on the development of mathematical thinking and logical reasoning (Amstrong, 2009). Both aspects can be stimulated by means of numbers but also through classifications and the hierarchical organization of elements, such as the classification of geographical places according to their climate and the processual presentation of 'states of matter,' amongst others. More specifically, the GBL methodology permits suggesting activities related to ordering, classifying, measuring, etc., through the use of some videogames which activate logical thinking and heuristics due to their contents and the implementation of problem-solving and solution-search strategies (Amstrong, 2009) –as it happens with puzzles. The ability to solve problems is one of the aspects that videogames most commonly tend to promote in relation to mathematical intelligence (Sedeño, 2010; Shute, Ventura, & Ke, 2015), the results obtained in this area illustrate how students activate their problem-solving skills using a commercial videogame.

The presentation of challenges in the form of questions, the Socratic method, enables users to apply mathematical strategies such as hypothesis formulation, accuracy, logical coherence, to name but a few. In this respect, Miller and Robertson (2010) highlighted the fact that brain-training games enhance mental calculation speed in younger players, as well as the degree of self-esteem linked to their achievements.

3.1 Videogames and the development of naturalistic intelligence

Concerning naturalistic intelligence, this is closely related to mathematical intelligence, insofar as it requires the development of skills such as problem solving. The existence of numerous videogames, which deal with scientific contents, can be easily verified too. Examples include Spore, about civilizations; Kokori, familiarisation with the inside of human cells; or Algodoo, aiding the learning of physics, to mention but a few (Sampedro & McMullin, 2015).

Considering that naturalistic intelligence consists of the ability to distinguish, classify and utilize elements related to the environment as well as to objects, animals or plants, and implies the skills associated with observation, experimentation and reflection about the physical environment (Ferrando, Ferrándiz, & Sánchez, 2005), the possibility exists to enhance this intelligence with videogames which promote such skills, e.g. experimentation games and simulators.

3.2 Videogames and the development of linguistic intelligence

Linguistic intelligence refers to the ability to manage and structure the meanings and functions both of specific words and of language as a whole. According to Antunes (2011), this intelligence becomes an essential tool for communication where mastering vocabulary and grammar plays an essential role. In this sense, games such as the Scribblenauts saga require a broad knowledge of vocabulary in the specific language needed to play, and they can prove useful to reduce the difficulty of expression, which derives from having a limited vocabulary in other languages. It should also be stressed that spoken as well as written language, together with narrative elements, constitute the foundations for play action shaping in RPGs (Role-Playing Games), thus contributing an improvement in this ability. The same applies to social videogames, as they require communication skills to interact with other players.

Along the same lines, a number of experiences have been oriented to favour language learning through fun applications based on training different linguistic skills (Karakus, Baydas, Gunay, Coban, & Goktas, 2016), which stress the motivating aspects of virtual worlds and videogames for this specific area. Thus, Ronimus, Kujala, Tolvanen and Lyytinen (2014) advocated using the

GBL methodology to encourage the learning of reading, taking advantage of the effects caused by engagement and the reward system as a means to increase its effectiveness.

The study presented here arises after verifying that the GBL methodology can serve as the basis to explicitly develop multiple intelligences (Kuk et al., 2012). More precisely, our aim consisted of checking the effectiveness of the Game to Learn Project, specifically oriented to the GBL-assisted activation of logical-mathematical, naturalistic, and linguistic intelligences in primary education. The involvement of teachers in that project actually required their simultaneous participation in a training activity, backed by the Centre for Training, Innovation and Educational Resources of Valencia, meant to provide them with the key didactic strategies and to exploit the educational opportunities implicit in videogames.

4 MATERIAL AND METHODS

4.1 Methodology

The present research is aimed at assessing the impact of the GBL methodology through the improvement of logical-mathematical, naturalistic, and linguistic intelligence levels amongst primary education students before and after taking part in the Game to Learn Project –implemented in 12 classrooms of different schools located in Valencia (Spain), with the collaboration of the TeacherTraining Service of the Valencian Regional Department of Education. The experience took eight months, dedicating one hour per week to playing with a selection of user-friendly and easily accessible educational videogames and/or digital games, the contents of which are connected with the curriculum, mainly with calculation, reading and writing, spelling (orthography) and vocabulary, for Spanish language subjects; the animal kingdom, geography and the human body for knowledge environment, all of which helped to reinforce conceptual and procedural learning.

For this purpose, teachers were offered a set of videogames available online on educational databases (See Table 1), hosted at the Ministry of Education, Culture and Sport website as well as on other websites of publishing companies (lafactoriainteractiva.com, lolapirindoladigital.com, etc.), or on sites promoted by Non-Governmental Organizations (enredate.org, belonging to UNICEF; chiltopia.com; vedoque.com; supersaber.com; etc.).

The videogames were grouped together according to the subject to which they belong, their contents and the intelligence development to which they contribute.

Table 1. Selection of micro-videogames utilized by teachers in the Game to Learn Project (elaborated by the authors)

Videogames	Contents	Connection with intelligences	Subject
La carrera del cálculo mental [The mental calculation race] http://www.supersaber.com/carreraMates.htm	Basic calculation	Logical-mathemat.	Mathematics
Atrapa al correcto [Catch the correct one] http://www.vedoque.com/juegos/granja-matematicas.html	Basic calculation	Logical-mathemat.	Mathematics
Moon maths http://smartboards.typepad.com/moonmaths.swf	Multiplications	Logical-mathemat.	Mathematics
Submarino monturiol [Monturiol Submarine] http://www.pequemates.es/pequemates6/contar_peces.html	Numbering	Logical-mathemat.	Mathematics
El reloj y las horas [The clock and the hours] http://concurso.cnice.mec.es/cnice2005/115_el_reloj/reloj/empezar.htm	Numbering	Logical-mathemat.	Mathematics
Velila al mando de la ortonave [Velila in charge of the orthoship] http://www.vedoque.com/juego.php?j=naves-ortografia.swf	Orthography	Linguistic	Language
Sensagent http://boggle.sensagent.com/boggle/index.jsp?dl=es&gl=es&pid	Vocabulary	Linguistic	Language
Ayuda a la lectoescritura [Help with reading and writing] http://www.juntadeandalucia.es/averroes/recursos_informaticos/proyectos2004/ale/index.html	Reading and Writing	Linguistic	Language
Sopa de letras [Letter soup] http://www.aguasdesevilla.com/infantil/infan/sopa.html	Vocabulary	Linguistic	Language
Arthur, hechos u opiniones [Arthur, facts and opinions] http://pbskids.org/arthur/games/factsopinions/factsopinions.html	English	Linguistic	Language
¿Conoces a los mamíferos? [Do you know mammals?] http://www.supersaber.com/carreraMAMIFEROS.htm	Fauna	Naturalistic	Environment knowledge
¿Qué comen los animales? [What do animals eat?] http://www.supersaber.com/zoo.htm	Fauna	Naturalista	Environment knowledge
¿Somos los dos iguales? http://ares.cnice.mec.es/ciengehi/a/00/animaciones/a_F_a00_01.html	The human body	Naturalista	Environment knowledge
El cuerpo humano [Are we two the same?] http://www.vedoque.com/juegos/juego.php?j=El-Cuerpo	The human body	Naturalista	Environment knowledge
Trivial de Europa [Trivial (Pursuit) about Europe] http://www.vedoque.com/juegos/trivial/trivial-europa.html	Geography	Naturalista	Environment knowledge

4.2 Participant sample

The sample included 119 primary education students belonging to 12 classrooms from a total of 7 educational centres located in Valencia, which participated in the Game to Learn Project, characterized by the adoption of the GBL methodology that will be referred to as the Experimental Group (EG). It must be highlighted that 46.7% of subjects are girls (and the remaining 53.3%, boys), 40.7% are 7 years old, followed by 8-year-olds (40.2%), 6-year-olds (8.9%), 9-year-olds (7.9%), and 5-year-olds (2.3%). Regarding their grades, the distribution is as follows: 3% from 3rd grade of primary education; 38.3% from 2nd grade; and 15.0% from 1st grade (Table 2). A control group (CG) formed by 12 subjects who did not take part in the aforementioned project was used to validate the information obtained.

As for the distribution of students within the sample, 21.5% were from Marni School (Valencia); 18.7% from Félix Rodríguez de la Fuente School (Manises); 16.8% from Villar Palasí School (Sagunto); 16.8% from Pinedo School (Pinedo); 15.0% from Artista Faller School (Valencia); 6.5% from Ausias March School (Picassent); and 4.7% from Salesianos San Antonio Abad School (Valencia).

4.3 Information collection tool

Seeking to assess the possible improvement in the logical-mathematical, naturalistic, and linguistic intelligences of each pupil prior and subsequently to their participation in the Game to Learn Project, 30 indicators associated with the three intelligences mentioned above (ten per intelligence) were extracted from the Evaluation Questionnaire,developed by Prieto and Ballester (2003). The teachers determined the level reached by students in each intelligence, with a 1-to-4 Likert scale (1=very low; 2=low; 3=high; 4=very high), showing their evolution in the competences and/or skills, which served to measure each one of them:

- Linguistic intelligence, evaluated from communicative competences referred to spoken and written language, reading skills, orthography and vocabulary.
- Logical-mathematical intelligence, evaluated from the competences linked to problem solving, calculation, arithmetic, object categorization, and higher-level cognitive processes, which become activated.
- Naturalistic intelligence, measured from the subjects' competence level with regard to scientific thinking –experimentation and investigation– and to the study of sciences.

The validated instrument obtained a Cronbach's alpha value of 0.928 for constructs. Principal component factor analysis was subsequently utilized to establish the viability of each construct in all three intelligences: linguistic (KMO=.931; Bartlett's sphericity test $p < .000$; explaining 62.952% of variance); logical-mathematical (KMO=.834; Bartlett's sphericity test $p < .000$; explaining 76.352% of variance); and scientific (KMO=.927; Bartlett's sphericity test $p < .000$; explaining 65.810% of variance). The previous results allow us to confirm construct viability, insofar as only one factor is created in each analysis. Confidence level reaches 95.0%.

4.4 Procedure

The teachers followed the procedure described in Figure 1 to work with the videogames selected for each subject in the classroom during a one-hour-long weekly session. They recorded each student's level in each one of the three aforementioned intelligences using the questionnaire developed by Prieto and Ballester (2003), at the beginning of the project (pretest: Phase 1) and at its end (retest: Phase 2) with the aim of assessing the evolution operated in each one of the three intelligences.

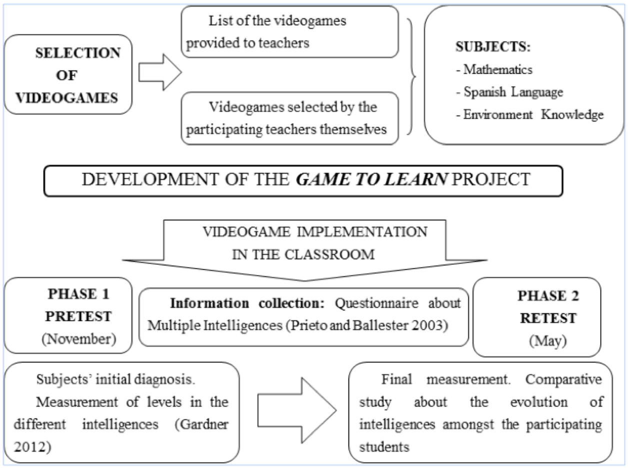

Figure 1. Phases in the development of the Game to Learn project (elaborated by the authors)

Concerning evaluation, it was already explained above that the participating teachers recorded students' levels in logical-mathematical, naturalistic, and linguistic intelligences, before and after taking part in the project, by means of the aforementioned 30-indicator qualitative instrument provided with a Likert-type scale specifically related to each intelligence.

Table 2. Sample distribution (N=119) according to grade and gender (elaborated by the authors)

Grade	Girls		Boys		Total
	Participants	C.G.	Participants	C.G.	
1st of Primary Ed.	2 (3.6%)	2 (20.0%)	2 (3.6%)	2 (20.0%)	8 (3.6%)
2nd of Primary Ed.	8 (14.5%)	2 (20.0%)	8 (14.5%)	2 (20.0%)	20 (14.5%)
3rd of Primary Ed.	15 (27.3%)	2 (20.0%)	22 (40.0%)	2 (20.0%)	41 (33.6%)
4th of Primary Ed.	30 (54.5%)	4 (40.0%)	23 (41.8%)	4 (40.0%)	61 (48.2%)
Total	55 (50.0%)	10 (50.0%)	55 (50.0%)	10 (50.0%)	130 (100.0%)

An additional descriptive analysis was performed to contextualize the sample, together with bivariate correlations that made it possible to establish the links between each one of the variables. A final ANOVA technique served to analyse the differences between the participating groups, using the SPSS Statistics software package (v. 23).

5 RESULTS

5.1 Levels reached in the intelligences under analysis (Phase I-Phase II)

a. Logical-mathematical intelligence

The ten indicators, which served to assess the increase in logical-mathematical intelligence, were those determined by Del-Moral, Guzmán and Fernández (2014). The results confirm the improvement experienced amongst our subjects at the end of the Game to Learn project supported by the GBL methodology. Table 3 shows the distribution of subjects in percentage terms according to the level reached in the ten indicators associated with this type of intelligence. A widespread increase in logical-mathematical intelligence became clear when the project, developed on the basis of the GBL methodology, came to its conclusion.

Subjects concentrate around the 'high' level in indicators linked to the taste for 'Likes to do jigsaws and puzzles' (47.7%); 'Likes to order things establishing hierarchies or categories' (46.7%); 'Likes to simulate experiments and does so in a way that proves his/her ability to handle higher-level cognitive processes related to thinking' the same as 'Has a good sense of the cause-effect relationship for his/her age' (43.9%) and 'Finds the mathematical missions in the videogame interesting' (43.0%). As for the 'very high' level, indicators such as the interest aroused/raised by 'Enjoy mathematics lessons (30.8%); 'Likes to play games which require using strategies' (29.9%); 'Likes to simulate experiments and does so in a way that proves his/her ability to handle higher-level cognitive processes related to thinking' (27.1%); 'Likes to do jigsaws and puzzles' (26.2%); 'Has a good sense of the cause-effect relationship for his/her age' (24.3%); 'Asks many questions about how things work' (23.4%); 'Finds the mathematical missions in the videogame interesting,' as well as 'Likes to order things establishing hierarchies or categories' (20.6%) are the most outstanding ones.

b. Naturalistic intelligence

Similarly, a widespread growth is verified in all the indicators, which contributes to explaining naturalistic intelligence after the Game to Learn Project finished (See Table 4).

Table 3. Subject distribution in percentage terms according to the level reached in the indicators that help to explain logical-mathematical intelligence in both phases (elaborated by the authors)

Indicators	Phase I				Phase II			
	VL	L	H	VH	VL	L	H	VH
1. Asks many questions about how things work	19.6	32.7	29.9	17.8	11.2	29.0	35.5	24.3
2. Carries out quick mental calculations to solve the arithmetic problems in the videogame	15.0	42.1	29.0	14.0	10.3	39.3	37.4	13.1
3. Enjoys mathematics lessons	9.3	28.0	43.0	19.6	10.3	20.6	38.4	30.8
4. Finds the mathematical missions in the videogame interesting	8.4	33.6	41.1	16.8	7.5	29.0	43.0	20.6
5. Likes to play games which require using strategies	7.5	28.0	40.2	24.3	6.5	31.8	31.8	29.9
6. Likes to do jigsaws and puzzles	20.6	36.4	26.2	16.8	11.2	33.6	47.7	26.2
7. Likes to order things establishing hierarchies or categories	4.7	33.6	45.8	15.9	3.7	29.0	46.7	20.6
8. Likes to simulate experiments and does so in a way that proves his/her ability to handle higher-level cognitive processes related to thinking	2.8	28.0	45.8	23.4	3.7	25.2	43.9	27.1
9. His/her level of thinking is more abstract than that of his/her classmates of the same age	22.4	34.6	25.2	17.8	16.8	35.5	31.8	15.9
10. Has a good sense of the cause-effect relationship for his/her age	7.5	29.9	42.1	20.6	4.7	27.1	43.9	24.3

Vl=Very low; L= Low; H= High; Vh= Very high

Table 4. Subject distribution in percentage terms according to the level reached in the indicators that help to explain naturalistic intelligence in both phases (elaborated by the authors)

Indicators	Phase I				Phase II			
	VL	L	H	VH	VL	L	H	VH
1. Enjoys the videogame activities placed within the context of the Knowledge Environment subject	4.7	12.1	46.7	36.4	.9	9.3	45.8	43.9
2. Is curious, likes to pose questions, and seeks further information	15.0	36.4	32.7	15.9	10.3	25.2	41.1	23.4
3. Compares and classifies objects, materials, and things according to their physical properties	21.5	37.4	28.0	13.1	6.5	36.4	45.8	11.2
4. Usually predicts the outcome of experiences before carrying out or simulating them in the videogame	26.2	38.3	24.3	11.2	12.1	33.6	41.1	13.1
5. Likes to make or simulate experiments and observe the changes which take place	23.4	42.1	23.4	11.2	8.4	45.8	36.4	9.3
6. Has good skills when it comes to establishing cause-effect relationships	17.8	38.3	29.9	14.0	10.3	32.7	40.2	16.8
7. Details his/her explanations about the operation of things	20.6	37.4	30.8	11.2	15.0	35.5	34.6	15.0
8. Often asks “What would happen if…?”	31.8	37.4	21.5	9.3	13.1	36.4	37.4	13.1
9. Likes the simulation where new materials are handled in the videogame	10.3	27.1	41.1	21.5	4.7	23.4	42.1	29.9
10. Owns a broad knowledge about topics related to natural sciences	20.6	33.6	35.5	10.3	14.0	30.8	41.1	14.0

Vl=Very low; L=Low; H=High; Vh=Very high

Table 5. Subject distribution in percentage terms according to the level reached in the indicators that help to explain linguistic intelligence in both phases (elaborated by the authors)

Indicators	Phase I				Phase II			
	VL	L	H	VH	VL	L	H	VH
1. Writes better than the average student of his/her age	17.8	40.2	32.7	9.3	11.2	39.3	36.4	13.1
2. Makes up fantastic and funny stories	19.6	31.8	35.5	13.1	15.9	29.0	40.2	15.0
3. Has a good memory for names, places, dates, and other types of information	7.5	29.9	45.8	16.8	7.5	29.0	41.1	22.4
4. Likes puns	5.6	18.7	54.2	21.5	7.5	15.0	46.7	30.8
5. Likes to read	13.1	29.9	38.3	18.7	8.4	23.4	43.9	24.3
6. Has good spelling	3.7	32.7	41.1	22.4	2.8	26.2	47.7	23.4
7. Likes rhymes, tongue twisters, etc.	22.4	28.0	32.7	16.8	7.5	38.3	37.4	16.8
8. Enjoys listening to the spoken word (narrations in the videogame)	30.8	35.5	23.4	10.3	20.6	38.3	31.8	9.3
9. Has a high vocabulary level for his/her age	28.0	27.1	31.8	13.1	21.5	33.6	29.0	15.9
10. Likes to communicate using spoken language	22.4	31.8	26.2	19.6	12.1	38.3	28.0	21.5

Vl=Very low; L=Low; H=High; Vh=Very high

The indicators which stand out the most at the ‘high’ level after the participation in the Game to Learn Project focused on the GBL methodology is ‘Enjoys the videogame activities placed within the context of the Knowledge Environment subject’ along with ‘Compares and classifies objects, materials, and things according to their physical properties’ (45.8%); ‘Likes the simulation where new materials are handled in the videogame’ (42.1%); ‘Is curious, likes to pose questions, and seeks further information’ the same as ‘Usually predicts the outcome of experiences before carrying out or simulating them in the videogame’ the same as ‘Owns a broad knowledge about topics related to natural sciences’ (41.1%); ‘Has good skills when it comes to establishing cause-effect relationships’ (40.2%). Regarding the ‘very high’ level, indicators such as the interest aroused by ‘enjoyment of videogame activities linked to the Knowledge Environment subject’ (43.9%), followed by ‘Likes the simulation where new materials are handled in the videogame’ (29.9%) and ‘is curious, ‘Likes to make or simulate experiments and observe the changes which take place’ (23.4%) stand out from the rest.

c. Linguistic intelligence

In turn, Table 5 presents the distribution of subjects in percentage terms according to the level attained in each one of the ten indicators, which helps to explain linguistic intelligence, where it becomes visible that our subjects experienced a qualitative improvement after participating in the Game to Learn Project that advocated the utilization of a GBL methodology.

All subjects improved from one phase to the other; it is worth highlighting how, on the 'high' level, they improved in the indicators 'Has good spelling' (47.7%), 'Likes puns' (46.7%) 'Likes to read' (43.9%), 'Has a good memory for names, places, dates, and other types of information' (41.1%) and 'Makes up fantastic and funny stories' (40.2%). As for the 'very high' level, the most outstanding indicator is 'likes puns' (30.8%), followed by 'Likes to read' (24.3%), that related 'Has good spelling' (23.4%) and 'Has a good memory for names, places, dates, and other types of information' (24.3%), all of them always with regard to aspects dealt with in digital games.

Table 6 illustrates the mean distribution and standard deviation for each listed intelligence It has become evident that the three intelligences under analysis in Phase II improved qualitatively.

Table 6. Mean distribution and standard deviations of the three intelligences in both phases (elaborated by the authors)

Indicators	Group	Phase I		Phase II	
		Mean	SD	Mean	SD
Linguistic	EG	2.60	0.88	2.95	0.88
	CG	2.75	1.12	2.57	1.08
Logical-mathematical	EG	2.59	0.87	2.94	0.92
	CG	2.48	1.10	2.87	1.00
Naturalistic	EG	2.52	0.87	2.91	0.86
	CG	2.48	1.02	2.85	1.05

Vl=Very low; L=Low; H=High; Vh=Very high

Analysing the mean values for each phase allows us to detect that they have improved for all intelligences in the second phase, where the highest value corresponded to linguistic intelligence (Mean=2.74; SD=0.89), followed by the logical-mathematical intelligence (Mean=2.68; SD=0.84) and the naturalistic one (Mean=2.66; SD=0.89), as can be seen in Figure 2.

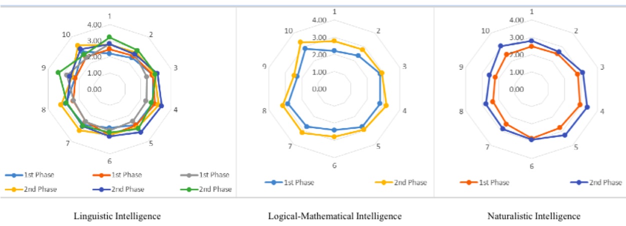

Figure 2. Distribution of intelligence means in both phases (elaborated by the authors)

The ANOVA technique revealed that the grade variable significantly influences the improvement of linguistic intelligence. The indicators improving are: 'writes better than the average student of his/her age' ($p < .001$); 'makes up fantastic and funny stories' ($p < .002$); 'has a higher vocabulary for his/her age' ($p < .001$); and 'has good spelling' ($p < .000$).

These are the indicators that turned out to be significant in the case of logical-mathematical intelligence: 'asks many questions about how things work' ($p < .016$); and 'finds the mathematical missions in the videogame interesting' ($p < .006$).

As for naturalistic intelligence, the following items stood out in relation to it: 'compares and classifies objects, materials and things according to their physical properties' ($p < .036$); and 'likes the simulation where new materials are manipulated in the videogame' ($p < .051$).

Finally, Student's t-test was applied for the purpose of determining whether differences existed between the experimental group and the control group, detecting that these two groups do not differ to a considerable extent, with a significance level of 95.0%. It can consequently be stated that this Game-Based Learning methodology contributes to explaining the improved intelligences in most schoolchildren, judging by the outcomes of Phase II.

5.2 Differences between sexes

Utilizing the ANOVA technique permits verification that significant differences appear as regards to linguistic intelligence in the indicator 'likes rhymes, tongue twisters, etc.' ($p < .014$), where boys do better than girls. Instead, the difference in the case of logical-mathematical intelligence lies in the indicator 'asks many questions about how things work' ($p < .028$), where girls outperform boys, and 'likes to play games which require using strategies' ($p < .049$), in which boys stand out. Finally, naturalistic intelligence only reveals significant differences in the indicator 'likes the simulation and virtual manipulation of new materials in the videogame' ($p < .050$) where boys have higher scores, as shown in Figure 3.

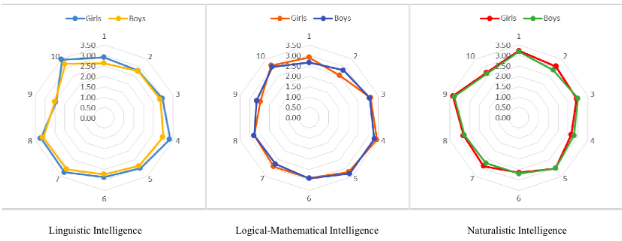

Figure 3. Distribution of intelligence means according to the sex variable (elaborated by the authors)

6 DISCUSSION AND CONCLUSSIONS

The Game to Learn Project made possible an enriching disruptive experience within the Primary Education context which led teachers from different school centres located in the Spanish province of Valencia to converge in the adoption of the GBL methodology in their classrooms, thus allowing them to work on specific contents belonging to the subjects of mathematics, Spanish language and environment knowledge from a selection of digital games, with a view to favour the development of Multiple Intelligences.

Therefore, the digital games utilized in the area of mathematics included activities and tasks related to calculation and numbering, where the time variable required speed and accuracy both to obtain rewards and to achieve success. These games recreate stories narrated by attractive characters who encourage players to work hard, promoting the calculation of elements linked to the script, with the aim of solving problems in a playful nature and successfully carrying out numbering tasks.

Similarly, the videogames associated with the area of Spanish language mostly revolve around puns, as well as vocabulary and spelling, in which the time variable also demands effort and speed when it comes to finding words, looking for synonyms, recognizing the meaning of those words, identifying how they are spelt, the drawings which represent them, etc. The presence of attractive characters and stories in some of the games equally implied an extra motivation.

In turn, videogames linked to the area of environment knowledge used encourages such practices as object comparisons and classifications, together with simulations that teach students to recognize and identify topics covered in the subject (knowledge of the human body, geography, flora and fauna, etc.), where the visual aspect of games emerged as an additional source of motivation. On the whole, these videogames succeeded in activating the skills and competences that are typical of intelligences directly related to the tasks, contents and skills required by such games. However, the time variable played a key role in improving students' performance in the areas of mathematics and language, along with the motivation inherent to the story, the characters, and success at overcoming the challenges posed.

The results provide evidence of a widespread improvement with regard to the three intelligences under study for all the subjects or areas of knowledge involved in the project. The 'high' and 'very high' levels bring together indicators that contribute to measuring linguistic intelligence, namely: enjoyment of listening to the voiceovers in video games' (71.0%); taste for communicating by means of spoken language (68.2%); preference for oral communication (68.2%); taste for rhymes, tongue twisters, etc. (67.3%); taste for puns (63.6%); and taste for reading (61.7%). By contrast, it must be highlighted that the indicators which turned out to be significant in the second stage are: enjoyment of listening to the voiceovers in videogames ($p < .000$) and taste for reading ($p < .000$), bearing in mind that the sex variable differs in the indicator 'likes rhymes, tongue twisters, etc.' ($p < .014$), where boys excel.

In the case of naturalistic intelligence, our subjects reach the highest levels in the following indicators: enjoyment of the videogame activities linked to the subject of Knowledge Environment (89.7%); taste for the simulation and virtual manipulation of new materials in the videogame (72.0%); and the fact of being curious as well as liking to pose questions and seeking further information (64.5%), standing out in Phase II with a significance level of 95.0%.

Similarly, after their participation in the Game to Learn Project, students attained 'high' scores in the indicators closely related to logical-mathematical intelligence, excelling in: interest in the mathematical missions of videogames (77.6%); taste for doing jigsaws (71.0%) and for games which require using strategies (68.2%), as well as the enjoyment of themes associated with mathematics (63.6%). In this case, only the indicator referring to the interest that mathematical missions in the videogame aroused in the student proved significant in the second phase. In relation to the sex variable, it can be verified that boys stand out in indicators such as: taste for the simulation and virtual manipulation of new materials in videogames ($p < .050$) and for games that require using strategies ($p < .049$), whereas girls excel in the indicator: asks many questions about how things work ($p < .028$).

Gender-based differences become visible in all intelligences after the end of the project: boys improve in linguistic intelligence, as shown by the taste for rhymes, tongue twisters, etc. ($p < .014$); in logical-mathematical intelligence, reflected in the preference for games which require using strategies ($p < .049$); and in the naturalistic one, illustrated by the taste for the simulation and virtual manipulation of new materials in videogames ($p < .050$). Instead, girls improve in logical-mathematical intelligence, with the indicator 'asks many questions about how things work' ($p < .028$).

Videogames obviously raise great interest amongst children, which is why it would be desirable for this GBL methodology to be adopted in educational centres, insofar as videogames can eventually become a powerful strategy not only to facilitate learning but also to improve skills and abilities –and consequently the different intelligences. More precisely, the outcomes of the present research provide evidence of significant improvements detected in naturalistic intelligence for boys as well as for girls, in linguistic intelligence for boys, and in the logical-mathematical one for girls.

Nevertheless, the success of such an innovative GBL methodology lies in the training of teachers, since they must learn to integrate these resources into the classroom, solving the various problems that are likely to emerge during that process.

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