

# Gamification in the process of cognitive stimulation in children with Down syndrome

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## ABSTRACT

This research studies the use of new information and communication technologies for the benefit of children with Down syndrome, it is about the design and programming of an application for mobile devices that stimulates playful interactions with the resource of gamification that takes advantage of the technological potential of video games in the educational field. Its interface was designed using Adobe Animate software with Action script programming language, designing two-dimensional animated graphics that encourage affective, cognitive and behavioral processes such as animals, their habitat and food; it also incorporates scenarios and sounds of easy grouping to encourage their academic activity in attention, visual retention and cognitive stimulation. The methodology used to design the first prototype was a survey of teachers, psychologists and language specialists of the Foundation for children with special abilities "San Miguel de Salcedo" FUNESAMI, who actively contributed in the development, structure, content and implementation of the application, which was evaluated with the active participation of 14 children with Down syndrome in average age of 6 to 12 years, The application was evaluated with the active participation of 14 children with Down syndrome with an average age of 6 to 12 years, finding remarkable improvements in the attention and retention that the child directs to the game, achieving an interaction that facilitates the teaching-learning process compared to the traditional method, thus contributing to the improvement of the quality of life and development of the child patient, thus complying with what is stated in the Constitution of Ecuador contributing to the good living.

**Keywords:** Down Syndrome, Inclusive Education, Video Games, Gamification, ICT.

## INTRODUCTION

Down syndrome, also called pair 21 trisomy, is not considered a disease. According to Rivas (2009), it is a genetic disorder caused by the presence of an extra copy of chromosome 21 (or a part of it), instead of the usual two (pair 21 trisomy) and is characterized by the presence of a variable degree of retardation and peculiar physical features, presenting physical and mental disability to varying degrees (Rivas, 2010), it is considered that in Ecuador, one out of every 550 children born alive has Down syndrome, a rate considerably higher than the average for Latin America, which is 1 out of every 700 children born alive (Navarrete, Guamán, Arteaga, & Guamán, 2019). Down Syndrome is the leading cause of intellectual disability in Ecuador. In 2010, the Manuela Espejo Solidarity Mission (a non-profit foundation that seeks to ensure comprehensive care for people with disabilities and their families), detected 7,457 people with Down Syndrome, of which 48.24% are women and 51.76% are men, of which only

20% have received comprehensive care in education and learning.

### Gamification and inclusive education for children with DS

This study aims at the inclusion of children with Down syndrome to integration and educational development through the use of new information and communication technologies by applying educational gamification processes to facilitate attention, visual retention and cognitive stimulation in children, joining the objective established by UNESCO (2008), highlighting the importance of establishing the integration of children with DS to the world of education and that this does not occur due to marginal aspects and other poverty needs (Vértiz, Pérez, Faustino, Vértiz, & Alain, 2019), according to Castillo et al. (2013), inclusive education is defined as: "a

philosophical, political, economic, social, cultural and pedagogical response that seeks to value and accept the differences of students within the school" (Castillo, Sosa, Rapallini, Blanc, & Leprat, 2019), this process arises from the individual student's need to feel recognized and taken into consideration in a reference group (Slava, Carlota, & Gonzales, 2015), for Mohammed (2019), this idea is becoming more and more widespread, since what is sought is the recognition of people with their vulnerabilities, as active beings capable of developing in a fair society that offers everyone the same opportunities (El Homrani, Arias, & Ávalos, 2019), it is essential to promote the development of a person with a disability in order to increase his/her possibilities of living, working with dignity, achieving independence and personal autonomy, Verdugo & Calvo (2012), mention that the paths to be considered to eliminate social barriers and improve the quality of life of people with disabilities is inclusive education. (Calvo & Verdugo, 2012), the same that must be assumed by the incorporation of ICT for the improvement of education, due to the high level of equal opportunities they have, if we take into account that they facilitate communication and interaction, regardless of the limitations of the students. (Fernandez, 2018), from this approach, Vértiz-Osores et al. (2019), mention that ICT allows the teacher to go beyond what was planned, since through the use of different tools the student can acquire other knowledge "the adoption of ICT is an opportunity that would contribute to the improvement of learning for students with disabilities, having as an endorsement the implementation of plans and improvements" (Vértiz, Pérez, Fautino, Vértiz, & Alain, 2019), in research conducted by Muñoz-Manjón et al. (2020), it is indicated that "55% of teachers frequently use ICT to carry out their teaching activities with students who have special educational needs (SEN), defining this term as those who present some difficulty in learning and require some type of temporary or permanent educational support" (Muñoz, 2020).

Rodríguez & Arroyo (2014) state that video games are an essential tool when it comes to enhancing the aspects that have to do with this competence. In addition, this tool promotes entertainment and motivation, which means that the socializing function is increased (Rodríguez & Arroyo, 2014), Faudoa (2016) specifies a widely accepted definition of gamification as: the degree and nature of interactivity that the game includes, i.e., how the player is able to interact with the virtual world and the way the virtual world reacts to the choices the player has made (Faudoa & García, 2016). There are many studies that demonstrate the effectiveness of computer use in the teaching and learning process, for example, Brinkley and Watson (1990) found that three-year-old performed object classification tasks more efficiently with computer simulation than with real objects (Brinkley & Watson, 1990), Clements & Samara (2002) showed that children who use the computer during arithmetic learning acquired higher level conceptual thinking than those who did it in a traditional way (Sarama & Clements, 2002). Langone et al. (1999), on the other hand, found that students with learning difficulties instructed with multimedia material performed better matching tasks than students who had been instructed without the use of this material (Langone, Jill, Clees, & Day, 1999), on the other hand, in the systematic teaching of writing, Alvarez (2015), considers the application of three very important stages in children with Down syndrome, i.e. in principle, the directions that usually should be respected are from top to bottom and from left to right, the tracing of the circle should be done in the direction that

will then facilitate writing the a, and d, linking them with the letters that are written next, therefore, it should be traced in the opposite direction to clockwise (Alvares & Ramirez, 2015), Garcia, et al. (2021), presents an educational and inclusive video game to stimulate mathematical skills in people with Down syndrome, along with an evaluation and feedback model based on game analytics, by means of a controlled test in which the results of the players coincided with the profiles assigned to each one in the simulation (García, Mejía, Salazar, & Gómez, 2019). In the contest "Your Ideas Your Initiatives 2016", organized by the Renault Group, students from Gimnasio Los Caobos school, located in Chía - Colombia, developed a video game designed for children with Down syndrome to learn traffic signs and thus avoid accidents, the video game is called Mission Street and in its evaluation it was found that children to take control of the character walking through the streets of a virtual city, quickly learned and interpreted the traffic signs and the correct way to travel (Medina, 2016), children can learn to multitask effectively. Currently there are many different video games for children that will teach them this important task of learning such as: "Diner Dash", "Cake Mania", "Virtual Villagers" and "Turbo Subs" as examples of gamification focused on the academic improvement of children with Down Syndrome (Navas, 2020).

## METHODOLOGY

The present research was formalized from a quantitative methodological approach based on a type of action-research, studying the perceptions and techniques used by teachers, psychologists and language specialists to determine the problem, as well as to address it through the use of technological educational tools. We start from the scientific method, according to Klimovsky (1998) "Methodology describes, validates, and in a way, prescribes a set of rules that the researcher must consider in order to construct and validate scientific knowledge" (Klimovsky, 1994), Hernandez (2010), states that "The quantitative method uses data collection to test hypotheses, based on numerical measurement and statistical analysis, to establish patterns of behavior and test theories" (Hernández, Collado, & Baptista, 2010), Hurtado & Toro (1998) point out that quantitative research has a linear conception, which implies clarity among the elements that make up the problem, which must be delimited and know exactly where they start from, in addition to recognizing what type of incidence exists among its elements (Hurtado & Toro, 2005). The methodological process of data collection and analysis was developed in the city of Salcedo, province of Cotopaxi, thanks to the active participation of members and collaborators of the Foundation for Children with Intellectual Disabilities "San Miguel de Salcedo" FUNESAMI, a non-profit institution specifically dedicated to assisting low-income children with intellectual disabilities.

As a first stage of the research, a quantitative diagnosis was carried out through the application of field research techniques for the collection of information with the application of 12 surveys addressed to the entire interdisciplinary team of professionals who selflessly support academic integration processes with analog and digital play activities, This allowed us to know in depth the problems suffered by children with DS and to propose technological alternatives to facilitate these processes, as well as to inquire in the sample group about the use of new technologies in the teaching-learning process in the resolution of conflicts of attention, visual retention and cognitive

stimulation.

For the design of the application, we propose the use of two-dimensional illustrations of animals, their habitat and their food, these elements were chosen after the analysis of some studies carried out in children with DS where it is demonstrated that animals are one of the first affective bonds of the child and encourage their attention and sense of responsibility (Berget & Braastad, 2011). This game allows them to respond nonverbally, which is more productive for them because they have problems with word articulation. On the other hand, the proposed interaction makes them feel that they are in control of the situation and this increases their self-esteem and security, in addition, it incorporates scenarios and sounds of easy grouping to encourage their activity in attention, visual retention and cognitive stimulation.

## RESULTS

With the results obtained from the surveys conducted with the group of experts and according to the evaluations of the sample group, it was possible to establish that the children with the greatest difficulties in speech, language, attention and retention are between 6 and 12 years of age, which is why 14 children were chosen, 8 boys and 6 girls. The total number of respondents recommended the use of new technologies through video games as an ideal strategy to encourage attention, visual retention and cognitive stimulation in children with DS with mild or moderate disabilities, and also referred to the importance of the use of two-dimensional images of animals illustrations for the affective and emotional bond that they generate.

An interactive application was designed and programmed for mobile devices that contains several educational games that will be updated periodically. It is worth mentioning that the research presents only one video game for evaluation, which proved to be

effective as a useful teaching tool to improve the cognitive ability to retain images through basic visual associations. The design of the application is called "Divertidown" and contains the prototype of the first experimental game called "my little pets", whose main function is to promote attention, visual retention and cognitive stimulation with the use of two-dimensional illustrations of animals, their environment and food.

The index or home page presents an animated and musical intro that automatically engages the child in navigation and experience, and includes buttons for easy access to the games. According to the group of experts, the innovation lies in the evaluation button where reports of the activities of each participant are generated by number of attempts and successes, the evaluation button is for the exclusive use of the therapists, who through this information monitor and evaluate the performance of the child in solving the challenges of the game, this will allow identifying the therapy that best suits the learning needs of each child. The game consists of 3 levels in which, prior to the evaluation, the children were instructed in the dynamics of the game.

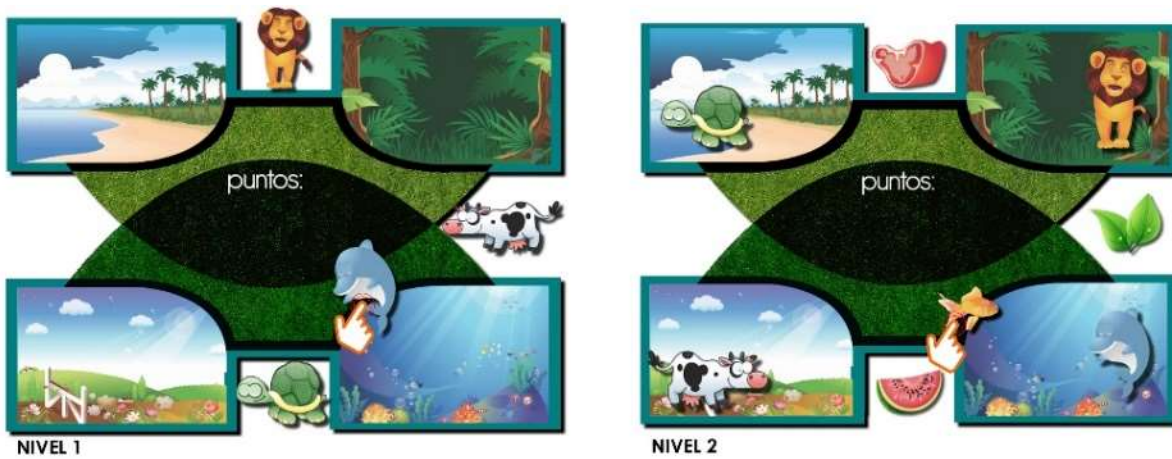
**Level 1** - In this level the child is presented with a scenario in which 12 animals appear in a sequence of 3 scenes with 4 associations each, the objective is that the child identifies the habitat that corresponds to each animal and with his finger drags it to the correct place, there are no limits on the number of attempts so that the therapists can evaluate the performance of each child.

**Level 2** - In this level the level of difficulty increases, once the animal is in its habitat it is necessary to feed it, for this the child must drag with his finger the food that corresponds to each animal.

**Level 3** - Once the challenges of levels 1 and 2 have been met, the child finds an interactive carousel where all the animals that were included in the game are present. Every time the child touches one of them, it emits its characteristic sound, awakening his affection and curiosity.



**Figure 1.** Index or home page design, including animation, music and interactive buttons to facilitate navigation and user experience



**Figure 2.** Level 1, scene 1, the first challenge of the game is to memorize the habitat of each animal and drag it to the corresponding place. Level 2, scene 1, the challenge of the game now is to bring the food to each animal and drag it to the corresponding place



**Figure 3.** Animated carousel, while turning the carousel the child can touch each animal and it emits its characteristic sound.

The video game was developed with the Adobe Animate platform, using the Action Script programming language, which allows the creation of vector animations, multimedia content, applications, games, etc, in an editing environment based on a timeline chronology in compatibility with HTML5, Canvas, WebGL, Snap.SVG, Adobe AIR and Flash format publishing and packaging, allowing the structure and content of the application to be responsive design for usability on any mobile device.

### Verification

In the application verification process, 14 children with DS participated, with ages ranging from 6 to 12 years, presenting an overall average of 9 years, these children correspond to the total number of children who regularly attend special education

therapies in speech and language. A comparison of the children by age before starting the teaching programs confirmed that the level of disability in the group was light or moderate and that there were no significant differences between them. We worked with 2 groups of 7 boys and girls, and in each session, we evaluated the children's performance in the principles of image association and retention through exercises in which they had to match each image of an animal with its habitat. The first group worked with traditional methodology in which the children were instructed with printed cards with which they had to match the elements that coincided, for example the lion and the jungle, the cow and the farm, the dolphin and the sea, etc., Initially the children were given a total of 8 printed cards, i.e. 4 with images of animals and 4 with images of their habitat for them to memorize the images and then associate them, in this way in the following sessions the number of images was increased with an

additional difficulty proposed in level 2, which is, in addition to the association of the animal with its habitat, the food is included, with a maximum of 12 animals.

In the second group, the usefulness of the interactive game and multimedia material to instruct the children in this association of elements of up to 4 objects at the beginning was verified and, gradually, the number of associations was increased in the same way as in the first group, but in this case with the novel and attractive function of interacting with a video game.

The results of the evaluation of the application in the therapeutic sessions are presented considering the analysis carried out during the interventions in which the traditional teaching method was applied to Group A, and the use of the video game to Group B. It

was determined that the evaluated groups responded satisfactorily to the video game, finding significant differences in each group in the execution of the different tasks that were presented to them.

Tables 1 and 2 summarize the results of the evaluation of group A, instructed with the traditional teaching method in which each child used printed cards of the animals, their habitat and food to combine them and meet the challenge in 5 attempts of association. In the first level, template 1, a result of 37.8% of correct answers was obtained in 5 attempts, and in the second level, template 1, taking into account that for this challenge the degree of complexity is increased by associating 3 elements, a result of 23% of correct answers was obtained.



Figure 4. Children with DS being instructed through the traditional method and with the video game.

Table 1. Percentage of hits in the association of the elements of level 1, first template, (animal/habitat), the traditional method was used.

GROUP A - TRADITIONAL METHOD - LEVEL 1 - FIRS TEAM								
PARTNERSHIPS	LION - FOREST		DOLPHIN - SEA		COW - FARM		TURTLE - BEACH	
	COINCIDENCENES	PERCENTAJE	COINCIDENCENES	PERCENTAJE	COINCIDENCENES	PERCENTAJE	COINCIDENCENES	PERCENTAJE
GIRL A	3	60%	2	40%	3	60%	1	20%
GIRL B	2	40%	3	60%	1	20%	2	40%
GIRL C	2	40%	2	40%	1	20%	2	40%
BOY D	1	20%	2	40%	2	40%	2	40%
BOY E	2	40%	1	20%	2	40%	1	20%
BOY F	3	60%	2	40%	3	60%	2	40%
BOY G	2	40%	2	40%	1	20%	1	20%
TOTAL	9	42,8%	3	40%	4	37,1%	4	31,4%
AVERAGE: 37,8%								

**Table 2.** Percentage of hits in the association of the elements of level 2, first template, (animal/habitat/food), the traditional method was used.

GROUP A – TRADITIONAL METHOD – LEVEL 2 – FIRS TEAM								
PARTNERSHIPS	LION – FOREST - MEAT		DOLPHIN – SEA - FISH		COW – FARM - LEAVES		TURTLE – BEACH - FRUIT	
5 ATTEMPTS	COINCIDENCES	PERCENTAGE	COINCIDENCES	PERCENTAGE	COINCIDENCES	PERCENTAGE	COINCIDENCES	PERCENTAGE
GIRL A	2	40%	1	20%	1	20%	1	20%
GIRL B	0	0%	0	0%	1	20%	0	0%
GIRL C	1	20%	2	40%	1	20%	1	20%
BOY D	1	20%	1	20%	2	40%	1	20%
BOY E	1	20%	1	20%	1	20%	0	0%
BOY F	2	40%	2	40%	1	20%	2	40%
BOY G	2	40%	2	40%	1	20%	1	20%
<b>TOTAL</b>	9	25,7%	3	25,7%	4	22,8%	4	17,1%
<b>AVERAGE: 23%</b>								

**Table 3.** Percentage of correct answers in the association of the elements of level 1, first template, (animal/habitat), the video game was used

GROUP B – USE OF THE VIDEO GAME – LEVEL 1 – SECOND TEAM								
PARTNERSHIPS	LION - FOREST		DOLPHIN - SEA		COW - FARM		TURTLE - BEACH	
5 ATTEMPTS	COINCIDENCES	PERCENTAGE	COINCIDENCES	PERCENTAGE	COINCIDENCES	PERCENTAGE	COINCIDENCES	PERCENTAGE
GIRL A	4	80%	3	40%	3	60%	2	40%
GIRL B	2	40%	3	60%	2	40%	2	40%
GIRL C	4	80%	4	80%	2	40%	2	40%
BOY D	3	60%	2	40%	4	80%	4	80%
BOY E	2	40%	2	20%	3	60%	3	60%
BOY F	3	60%	4	80%	3	60%	3	60%
BOY G	2	40%	3	60%	2	40%	1	20%
<b>TOTAL</b>	9	57,1%	3	62,8%	4	54,3%	4	48,5%
<b>AVERAGE: 55,7%</b>								

**Table 4.** Percentage of correct answers in the association of the elements of level 2, first template, (animal/habitat/food), the video game was used

GROUP B – USE OF THE VIDEO GAME – LEVEL 2 – SECOND TEAM								
PARTNERSHIPS	LION – FOREST - MEAT		DOLPHIN – SEA - FISH		COW – FARM - LEAVES		TURTLE – BEACH - FRUIT	
5 ATTEMPTS	COINCIDENCES	PERCENTAGE	COINCIDENCES	PERCENTAGE	COINCIDENCES	PERCENTAGE	COINCIDENCES	PERCENTAGE
GIRL A	3	60%	2	40%	3	60%	2	40%
GIRL B	2	40%	3	60%	2	40%	2	40%
GIRL C	3	60%	3	60%	2	40%	3	60%
BOY D	3	60%	2	40%	2	40%	2	40%
BOY E	3	60%	2	40%	1	20%	2	40%
BOY F	3	60%	2	40%	3	60%	2	40%
BOY G	2	40%	2	40%	2	40%	1	20%
<b>TOTAL</b>	9	54,3%	3	45,7%	4	42,8%	4	40%
<b>AVERAGE: 45,7%</b>								

Tables 3 and 4 summarize the results of the evaluation of group B, instructed in the experience and usability of the video game, in the same way as group A worked with the traditional method, 5 attempts of association were made, the results obtained show a substantial increase in the level of learning and percentage of successes in the associations of images to meet each challenge of the game, Thus, in the first level, template 1, a result of 55.7% of correct answers was obtained in 5 attempts, and in the second level,

template 1, with a higher degree of complexity by associating 3 elements, a result of 45.7% of correct answers was obtained. The results found completely support our hypothesis, showing the goodness of multimedia material in the acquisition of this type of content in people with DS. Although the performance of both groups was similar in all tasks before the beginning of the teaching, the group of children who learned through the use of the video game showed a substantial improvement after the training period.

## CONCLUSIONS

The work of collecting information with the interdisciplinary group of professionals was very enriching, since it allowed us to know in depth the learning problems suffered by children with DS and thus propose technological alternatives such as the design of an application with the experimentation of a video game to facilitate these teaching and learning processes.

An application called "Divertidown" was designed, which contains the prototype of the first experimental video game called "my little pets", the effectiveness of the intervention program with the participation of 14 boys and girls with DS divided into 2 groups, is based on the data obtained in the comparison between the results of the use of the traditional method with the gamification method that derived in significant differences, demonstrating that the use of the video game increased the number of hits in the association of the elements present in level 1 and 2.

The present research shows that the video game effectively captured the children's attention, especially because animals are included as the first affective links, promoting interest and capture in the mode of use, which allowed encouraging their attention, sense of responsibility, conflict resolution, visual retention and cognitive stimulation, including coping with stress.

The present research work has a specific social connotation towards the benefit of the application of technology in the cognitive development of children with DS, the research continues in the development of gamified proposals through augmented reality and artificial intelligence, which allow to advance in the satisfactory development of motor skills in children with DS.

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