*Article*

# Design Thinking: Methodological Strategy for the Creation of a Playful Application for Children with Dyslexia

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**Abstract:** The use of a methodology to address a problem facilitates work in an efficient, effective, and highly productive way. The design thinking methodology (also known as design thinking) is user-centric and oriented towards offering solutions by breaking down a problem into small parts to analyze it, to explore it, to test the results, and to create solutions that benefit the end-user. Many children have problems related to learning disorders, such as dyslexia, which occur due to the way that their brain incorporates and processes information. This can lead to them showing difficulty in some learning areas, even when their intelligence or motivation does not appear to be affected. In this research, through a mixed approach, a playful application is developed using new information and communication technologies (ICT), following a design thinking methodology, with the aim of supporting the learning of children with dyslexia through content designed with respect to their needs in order to help improve their academic performance. Data collection was carried out through observation, an interview, and record reviews. Analysis of the didactic materials allowed for the observation that content designed for the specific needs of children can work as a reinforcement for incorporating the information in an entertaining, dynamic, and friendly way, ultimately contributing to improved academic performance.

**Keywords:** design thinking; dyslexia; learning

## 1. Introduction

At present, educational processes consist of a continuous cycle of activities, where not only the generation and incorporation of new learning, multiple knowledge, experiences, skills, and attitudes, but also technological skills—which are critically necessary in this mediated world—are encouraged by information and communication technologies (ICT).

The first years of life in human beings constitute a stage with unique characteristics: a period when the foundations for physical and spiritual development are laid since it is during early childhood when knowledge, skills, abilities, and habits are assimilated. In addition, volitional–moral capacities and qualities are formed, which was previously thought to occur at older ages [1].

Equality within and outside of classrooms is a challenge that has been considered for a long time in the educational system. The inclusion of people with special educational needs associated and not associated with a disability in regular education has precipitated a group of pedagogical changes, whereby it is necessary to precisely understand what deficiencies students present in order to be able to adapt them to the current educational regime [2].

Educational inclusion is a factor of utmost importance to be considered by all stakeholders within the educational system; hence, there is a constant need to analyze, in different conditions, how this work should be carried out such that no-one is excluded. Moreover, there is a need for schools to be a space for the co-construction of interpersonal relationships, where respect and acceptance of others is promoted, and which offers a

situation that benefits not only the included, but also those who are part of the inclusion process [3].

In the educational field, the concept of special educational needs is frequently used to distinguish all of those students who have difficulties progressing in learning and achieving curricular objectives, for which they need to receive special help and support (either temporarily or permanently) in the most normalized educational context possible [4], with the understanding that these needs are motivated by a wide variety of factors, such as late integration into the educational system, disabilities, or serious conduct disorders, to name a few.

Many people have educational needs such as dyslexia, which, according to the Diagnostic and Statistical Manual of Mental Disorders (DSM-V), is an alternative term used to refer to a pattern of learning difficulties characterized by problems with the recognition of words in precise or fluent form, misspelling, and poor spelling ability [5].

Technologies have brought many significant changes to productive areas, having economic, cultural, psychosocial, and educational impacts. ICT can serve as a mediating resource in the classroom and has become a tool of great academic support, enabling the incorporation of knowledge and strengthening the skills and abilities of those involved.

The new roles that both teachers and students must perform in the classroom entail adopting and adapting ICTs to the educational process in order to generate environments that seek to improve the models and paradigms of teaching in action [6].

In this regard, Romero et al. [7] have mentioned that the convergence of ICT in teaching–learning processes has meant that their adapation is essential in the different contexts and educational needs that we face.

ICTs have been shown to be very useful in the educational field in general and, in particular, in their use with people having special educational needs, such as those who suffer from dyslexia, resulting in improved development of their learning, social development, and better adaptation into the environment that surrounds them.

For a long time, games have served as a form of instruction and education among human beings, and as a basic exercise for understanding part of the social teaching that different cultures provide to their members. They have been considered voluntary and fundamentally social activities, in which one is in relationship with other individuals, learning norms of values and behavior.

Games, as a playful strategy, can guide the active participation of students, as they are creations designed so that children can ascribe meaning to the natural and social worlds that surrounds them while, at the same time, constituting a learning resource and a research strategy for understanding the more complex physical world, social relationships, the distribution of time, and the pedagogical environment [8].

Didactic games, as a form of inclusive teaching, enable the increased motivation of those who participate in them, improving the task they are carrying out at the time and fulfilling the objectives set during a certain class or topic; therefore, the idea is to demonstrate that activities are focused on improving student performance [9].

School or academic performance, in their dynamic aspect, respond to the learning process. As such, they are linked to the ability and effort of the student: in their static aspect, they comprise the product of the learning generated by the student and, therefore, express the use of the influences used in the teaching–learning process at its different levels of concretization [10].

The application of didactic games with well-defined objectives and activities for certain classes—mainly to improve academic performance in various subjects—is a valuable resource for the student body [9].

Making use of ICT for the creation of playful applications for educational purposes can be of great help for students, as their learning transforms into a form of entertainment, helping them to understand many of the topics they review in their classroom activities in a fun way. Playful applications designed to support student that have a special educational

need are of great importance to their learning, as many of them need to work continuously with content to improve their academic performance.

Thus, well-planned didactic games with clearly defined objectives make it possible to attract the attention of students, helping to improve their grades and, consequently, improving their overall academic performance.

## 2. Context

Among the special educational needs that a person may present, such as learning disorders, persist throughout the life of those who suffer from it and generate difficulties that affect the ability of the individual student to process, analyze, and store the information received, despite possessing an according intelligence for their age and adequate socio-cultural conditions to give way to learning contexts [11].

Dyslexia is considered a part of learning disorders, and many authors have attempted to define it.

In 1979, Mozota defined dyslexia as any durable and specific difficulty regarding literacy in children without sensory or motor deficits and with IQ appropriate to their age, characterized by spelling and reading errors caused by localized injury in the natural pathway of the auditory–vestibular language [12].

In 1990, Cuetos, in his book "Psychology of Reading", alluded to the concept of dyslexia, considering that—although the range of causes may be diverse—the concept implies, in neurological terms, that dyslexia is due to brain dysfunction, presenting as difficulties which are specific to reading [13].

Rosen, Sherman, and Galaburda, in 1993, defined developmental dyslexia as a primary disturbance in the acquisition and performance of reading skills [14].

The National Institute of Neurological Disorders and Stroke (NINDS) of the United States of America [15] described dyslexia as a type of brain-based learning disability that specifically affects a person's ability to read, noting that these people do so at significantly lower levels than expected, despite having average intelligence, presenting difficulty with reading, phonological processing (manipulation of sounds), spelling, and/or rapid visual–verbal response.

In the International Statistical Classification of Diseases and Health Problems (ICD-10), dyslexia (or specific reading disorder) is included within the specific developmental disorders of school learning, the main characteristic of which is a specific and significant deterioration in the development of reading skills, which alters the ability to understand reading, the ability to recognize written words (through reading), the ability to read orally, and the performance of tasks that require reading [16].

Likewise, the International Dyslexia Association [17] considers it to be a specific learning disability of neurobiological origin, characterized by difficulties with accurate and/or fluent word recognition, along with poor spelling and decoding.

In this regard, Pinto [18] has pointed out that, among the main characteristics observed in children with dyslexia, there are difficulties in phonological awareness (rhymes, phonemic segmentation, and transposition), as well as changes in the speed of naming of verbal material and phonological memory of work or problems in the selection of cognitive resources necessary for the processing of visual information, among others.

A dyslexic child in the classroom presents very particular characteristics, as they are often disorganized and distracted. They find it difficult to formulate and structure a story, to tell it, or to write it; they tend to waste time before starting to carry out a certain task; and/or they take a long time to carry out writing tasks, to name a few [19].

The International Dyslexia Association [17] has noted that dyslexia affects 1 in 10 people worldwide, many of whom remain undiagnosed and receive little or no intervention services; for its part, the Dyslexia Mexico portal [20] has mentioned that, in the Mexico, 3 out of 10 children suffer from this learning disorder.

Due to the characteristics of children with learning disorders, such as dyslexics, very particular attention is needed in their teaching–learning process, requiring work with an

agenda supervised by the teacher and the family, using manipulative and visual teaching materials, using alternative formats to the written text for the presentation of works or tasks or to promote, in the classroom, assistive technology and software appropriate to their difficulties [21].

In the city of Villahermosa Tabasco, Mexico, there are some Institutions in charge of helping children with dyslexia problems, including the Resource and Information Center for Educational Integration (CRIE), whose purpose is to provide guidance and provide educational resources to parents and teachers who serve students with special educational needs with or without disabilities.

In students who are screened for dyslexia by the CRIE, some particular characteristics of this learning disorder were observed, such as difficulty in decoding written ideas, as well as stopping and/or spending a long time observing words or small texts in order to read what they represent, thus causing them to omit letters, confuse them, or change them for others.

The learning activities that the teachers carry out with these students vary, according to the subject being addressed, using didactic resources such as puzzles, word-searches, word mastery, and word bank or rhyming activities, to name a few.

Considering the aforementioned characteristics and the educational needs presented by these children, which demand that the associated materials are specifically designed to address their literacy deficiencies, the objective of this research was to use the design thinking methodology and ICT to build a playful application that helps children with dyslexia to learn through the use of an educational content designed for their needs, with the ultimate goal of improving their academic performance.

For people with dyslexia, literacy is a task that requires more time and effort as it involves a greater activation of attention and memory to be able to fulfill their learning activities.

## 3. Design Thinking as a Methodological Strategy

In the vulnerable times that humanity lives in at present, having meaningful and life-long learning has emerged as one of the most important and difficult challenges for the educational systems of many countries, and it is urgently required that educational professionals promote the construction of coexistence and connection with their students.

Rodríguez, Moya, and Rodríguez [22] have considered that the practice of empathy by teachers should emerge as one of the essential values in the classroom, developing the ability to perceive emotions, feelings, and sensations, in addition to adopting efficient approaches and knowledge regarding the ways of thinking and acting toward each of their pupils.

At present, there is talk of innovating educational processes at all school levels, including the appropriate use of ICT, regarding the needs of students who are now born surrounded by technology; furthermore, it is also necessary to use new methodologies to find solutions to the current challenges arising around the associated teaching–learning process.

Design thinking is a methodology that is centered on the human being, based on an understanding of the needs and motivations of individuals, establishing the ability to combine empathy (with the context of a problem), creativity (in the generation of ideas, perceptions, and solutions), and rationality in order to analyze and combine the solutions with the context [23].

In this regard, Urroz [24] has mentioned that design thinking is a user-centric, collaborative design methodology based on empathy that is committed to the development of prototypes to contrast its effectiveness, which does not follow a linear thought process, and which advocates for the collaboration of various fields to determine the best solution, as it is oriented to the innovation of products, spaces, and services through creativity.

The term 'design thinking' appeared for the first time in 1969, when it was coined by Herbert Simon (Nobel Prize in Economics), in his book "The Science of the Artificial".

However, this term was forgotten for a long period of time until, in 2008, a professor at Stanford University, Tim Brown, wrote a paper in which he developed the methodology initiated by Herbert Simon [25].

In 1990, design thinking reached its heyday, thanks to contributions from the Stanford University School of Design, carried out by the IDEO company, which is a company dedicated to innovation and user-centered design of products, services, processes and environments. It was the first to develop the terminology, steps, and manuals relating to this methodology. Since 2005, it has been taught at said university in what is now known as the Hasso Plattner Institute of Design. This reality has impacted other prestigious universities, which have adopted and applied it to other broader fields, considering that design is a process that participates in all dimensions of human life [26].

Initially, this methodology was associated with business issues; however, its creative and innovative approach has allowed for its use in other work sectors (e.g., medicine and education), as it focuses on both human beings and innovation, based on tools used by designers to integrate the needs of people, supported by the benefits of technology [27].

In the current world, with ample technology to solve complex situations, as well as everyday situations, it is important to consider that design thinking can contribute to forming more creative and competent students, as the traditionally used exhibitor–receiver method of teaching in the classroom has become obsolete in these times; in contrast, students are required to think about, analyze, and propose solutions to the problems that arise.

In the field of education, the design thinking methodology has aroused interest as it promotes the adoption of knowledge, meaningful learning, and the development of key competencies to function in the current professional context, such as creativity, communication, learning to learn, work collaboration, and problem solving [26], thus allowing for the educational needs of each student to be accurately identified and to generate educational experience according to their individual needs.

### 3.1. Stages of Design Thinking

The design thinking process is mainly composed of five stages which, as mentioned in the Design Thinking Community portal [25], comprises a non-linear process. This means that one can iterate and go back through the phases if the considered project requires it (see Figure 1).



**Figure 1.** Stages of the design thinking methodology.

The design thinking methodology consists of five stages—empathize, define, devise, prototype, and evaluate—which are defined in Table 1, according to Murcia and Hernández [28], CIBBVA [29], and Rodríguez [26], which are very useful for giving attention to the needs of educational activities required by children with dyslexia.

**Table 1.** Description of the stages of the design thinking methodology [27,29,30].

| Stage | Description |
|---|---|
| Empathize | This stage begins with a deep understanding of the needs of the users involved in the solution that has being developed, as well as of their environment. Thus, they must be observed, listened to, and understood, in an attempt to obtain as much information as possible and to learn about the user in detail. |
| Define | In this stage, the information collected during the Empathize phase must be filtered to leave only what really adds value in order to clearly define the problem and to satisfy the needs detected through creativity. |
| Devise | Once the problem is defined, a process for generating the maximum amount of ideas to solve or treat it begins, allowing divergent thinking to be favored and eliminating value judgments. |
| Prototype | In this stage, the ideas are passed into reality. Once they have solutions to the problem, the relevant teams must work to build prototypes which make the ideas palpable, highlighting elements that must be improved or refined before reaching the final result. |
| Evaluate | At this stage, it is essential to have the designed prototype, which will be exposed to other people in the same context and to whom it would be directed, such that they can interact with it, experiment, and give feedback, which will help to identify significant improvements, faults to be resolved, and possible shortcomings. During this phase, the idea evolves until it becomes the solution that is sought. |

*3.2. Techniques Used in the Design Thinking Stages*

In the various stages of design thinking, techniques that are very useful for discovering and selecting educational needs are used, which serve to propose prototype solutions, aimed at the population that requires it.

Table 2 shows some techniques used in the different stages of the methodology, which can be applied depending on the population considered [30,31].

**Table 2.** Some techniques used in the design thinking stages [27,29,30].

| Techniques Used in the Different Stages of the Methodology | |
|---|---|
| **Stage** | **Description** |
| Empathize | In this stage, several techniques can be used to achieve an approach to the problem, including the Stakeholder Map, Interview, Priority Diagram, Mind Map, Storytelling, Covert Observation, Empathy Map, and Selection by classification, among others. |
| Define | In the Define stage, the used techniques include Cognitive Immersion, Interviews with photos, Mood board, Mind Map, Competency Analysis, Clustering, Context Maps, and User Interaction Maps, to name a few. |
| Devise | For this stage, it is recommended that techniques such as Selection of ideas, Value curves, Raw prototype, Models, Group drawing, Use-case diagram, Brainstorming, Priority diagram, among others, are used. |
| Prototype | At this stage, various techniques can be used in the construction of the prototype versions for the solution, among which are Use-Cases, Group Drawing, Raw Prototype, Image Prototype, Paper App Prototyping, System Map, and Rapid Prototyping, to name a few. |
| Evaluate | For the testing or evaluating stage, techniques such as Extreme Users, Usability Testing, Focus Groups, Covert Observation, Test Notes, and Experience Evaluation, among others, can be used. |

## 4. Materials and Methods

For this research, we carried out a mixed approach, where ICTs were used to develop a playful application following the design thinking methodology. Hernández-Sampieri and Mendoza [32] have mentioned that mixed methods represent a set of systematic, empirical, and critical research processes involving both data collection and quantitative and qualitative data analyses, as well as their integration and joint discussion, to draw inferences based on all of the information collected and achieve a better understanding of the phenomenon under study.

As part of the research, and in order to understand the problem, it was necessary to observe the behavior of the target population in their educational development environment, through analyzing the processes that children with dyslexia follow when interacting with the didactic materials they used during the course in the classroom, and whether they were useful for the learning topics. Thus, it was also necessary to investigate their academic performance before and after using the playful application, which was designed specifically for them.

*4.1. Participants*

As mentioned above, in Mexico, there is institutions which are in charge of helping students with disabilities, who receive support in basic education through the Resource and Information Center for Educational Integration (CRIE), the Service and Support Units for Education Regular (USAER), or through Multiple Attention Centers (CAM) [33].

The Center of Resources and Information for Educational Integration (CRIE) offers information, advice, and training to the personnel of the National Educational System, Families, and the Community regarding educational options and care strategies for people with special educational needs, providing guidance on the use of various specific materials to respond to the educational needs of these people, as well as developing investigative studies in order to eliminate barriers to learning and participation in schools [34].

It is worth mentioning that, in the CRIE, children who have any special educational needs have been identified and grouped, with respect to which they are given attention according to the considered problem.

The children who participated in this research belonged to the CRIE, from the municipality of the Center of the state of Tabasco in the Mexican republic, which was authorized by the director in charge of this educational center, who was asked for support and to who we explained the benefits that would be received through the use of a playful app by children with dyslexia. Thus, approval to carry out this work was also obtained from the review commission assigned to this project.

The population that was used as a sample in this research work was made up of 9 students from CRIE, from the municipality of Centro, in Tabasco, Mexico. The ages of these children fluctuated between 5 and 8 years, as well as one 13-year-old adolescent. The individuals which we worked with also participated in a pilot study to test the scope of the application developed in this research. It is worth mentioning that most of these children come from low-income families.

It is important to point out that, to attend to these children, we collaborated with two teachers, who developed and provided the didactic materials that dyslexic children use in the classroom.

*4.2. Instrument*

Data collection is of utmost importance in research, as it allows for the identification of the primary or secondary data sources of a social group, institution, or company in order to obtain useful information for decision making.

Hernández and Duana [35] have reported that data collection techniques include procedures and activities that allow the researcher to obtain the necessary information to answer their research question.

In order to detect the needs of the children with dyslexia who participated in this research, we used an interview, observations, and a review of records as tools for data collection.

For the purpose of understanding the educational problems faced by the dyslexic children in the study sample, the teachers in charge of teaching them were interviewed twice in order to determine the difficulties they presented when interacting with the learning activities that were carried out. The interviews were conducted in the classroom.

These interviews revealed important aspects, including the following: The children had difficulty spelling, found it difficult to pronounce unfamiliar words, presented a somewhat poor reading level, had trouble remembering sequences of words or things, showed insecurity in activities involving reading, and showed difficulty in finding correct words, to mention a few.

To understand the process was carried out in the classroom by the children when interacting with the materials that the teachers provided them, direct observations were provided. This activity made it possible to identify the materials that the children used, the instructions that were given, the time that the activity lasted, the time the child invested in carrying out a task, and their preferences, with respect to the activities by subject area.

As part of the design thinking methodology, several prototype applications were developed, until a playful application relevant to the needs of dyslexic children was obtained, which was provided to them in the classroom. They were expected use the developed application as a complementary teaching material, which made it possible to verify their academic performance before and after using it. For this purpose, we reviewed the evaluations of their learning activities that their teachers had made.

## 5. Results of Modeling with Design Thinking

As mentioned above, design thinking is a user-centered methodology which offers solutions by breaking down a problem into small parts, allowing one to analyze and detect educational needs.

Taking into account the five stages described above, in which various techniques can be used for development, the data were modeled to create several prototypes prior to the final version of the playful application, with the purpose of serving as didactic support with respect to the educational needs of children with dyslexia.

The activities carried out in each of the stages are described below:

### 5.1. Empathize Stage

At this stage, it is required that the researcher places themself in the shoes of dyslexic children in order to understand the problem where they require educational support, to know the teaching materials and tools they use, the teaching activities carried out, the difficulties they have in carrying them out, their tastes and skills, and the issues that were addressed, as well as the requirements to overcome this situation.

Table 3 details the techniques used in this stage, which were very useful for developing an understanding of children with dyslexia.

**Table 3.** Description of techniques used in the Empathize stage.

| Techniques Used for the Empathize Stage | |
|---|---|
| **Techniques** | **Description** |
| Covert Observation | Through covert observation, we sought to obtain objective information at the time that the children with dyslexia carried out their learning activities, without interfering with the class; that is, in such a way that some type of influence was not caused. |
| Interview | An interview was carried out with the teachers in charge of guiding the children's teaching. |

### 5.2. Define Stage

The information collected in the previous stage was analyzed and refined, prioritizing that which was most useful in order to address the thematic areas that were identified as priority and necessary, in which dyslexic children required attention and that is expected to aid in their learning process.

Table 4 lists the techniques used for this stage that served to identify the useful information, which could be captured in the playful application.

### 5.3. Devise Stage

In this stage, designs were made through the use of drawings and diagrams which represented the needs detected in the dyslexic children, integrating thematic areas with their elements. This resulted in designs which would be not only be useful in learning but were also attractive. Table 5 presents the techniques that were used in the design considering the information collected.

**Table 4.** Description of techniques used in the Define stage.

| Techniques Used for the Define Stage | |
|---|---|
| **Techniques** | **Description** |
| User Interaction Map | By means of a User Interaction Map, it was possible to identify and analyze the different tasks that the children performed in the various activities of their learning, as well as their interactions with the associated contents. |
| Context Maps | The Context Map was very useful for locating the reality in which these children with dyslexia develop, analyzing the particular characteristics that this population presents and the environment where they develop. |
| Mood board | With the use of a Mood board, it was possible to analyze and select the visual elements (e.g., images, photographs, texts) that were used in the classroom in their learning activities, and which served to be integrated into the prototype solution. |

**Table 5.** Description of techniques used in the Devise stage.

| Techniques Used for the Devise Stage | |
|---|---|
| **Techniques** | **Description** |
| Selection of ideas | With the selection of ideas technique, it was possible to explore the possible viable solutions to be developed in the digital prototype for the playful application. |
| Priority Diagram | The Priority Diagram was used to give an order to the topics that would be included in the prototype, as well as the elements necessary for each topic. |
| Use-Case Diagram | Use-case diagrams allowed for the different elements of the initial prototype and the interactions between the various thematic modules to be graphically visualized. |

Figure 2 shows one of the use-case diagrams which were constructed in order to organize the information, thus enabling a description of the interactions that may exist between the different options that a child with dyslexia may use.
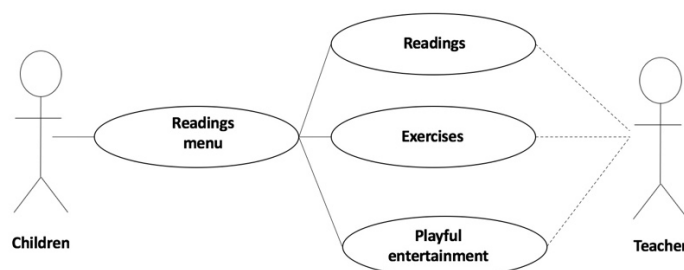


**Figure 2.** Example use-case diagram noting detected needs.

*5.4. Prototype Stage*

In this stage, the development of the ideas obtained in the previous stage commenced through the creation of a prototype application, organized in terms of themes, images, colors, sounds, and texts, which were included according to the learning activities of the students with dyslexia in the classroom.

Table 6 presents the techniques used to develop the prototypes in order to obtain the playful application for the dyslexic children of the CRIE.

**Table 6.** Description of techniques used in the Prototype stage.

| Techniques Used for the Prototype Stage | |
|---|---|
| **Techniques** | **Description** |
| Prototyping of Apps on paper | Through the Prototyping of Apps on paper, the screens that would contain the test prototypes were designed, before obtaining the final playful application. |
| Rapid Prototyping | A Priority Diagram was used to give an order to the topics that would be included in the prototypes, as well as the necessary elements for each topic. |

In this stage, prototype designs for the organization and distribution of the screens of the playful application were made in such a way that the order indicated by the use-case diagrams—carried out in the previous phase—was continued. It was designed such that it could be viewed on different technological devices, such as computers, mobile phones, or tablets.

These screens were used to sketch an approach to what would be conducted using the Adobe Animate Creative Cloud software in order to develop the first stages of the prototype. It integrated the previously defined modules as well as the learning activities included in each of them, organized by thematic areas.

To realize the playful application, it was necessary to have a vision for the application. This is why a software engineering process is important, which is responsible for defining a model to control the life cycle of the software and the programming to be used, as well as the methodology for the design of the software content.

For this research, a prototype model was chosen, also known as an evolutionary model (see Figure 3), which consists of developing the concept of the system as the project progresses. It began by developing the most visible aspects of the system. The already developed part of the system is then presented to the user, and the development of the prototype continues based on the feedback received [36].
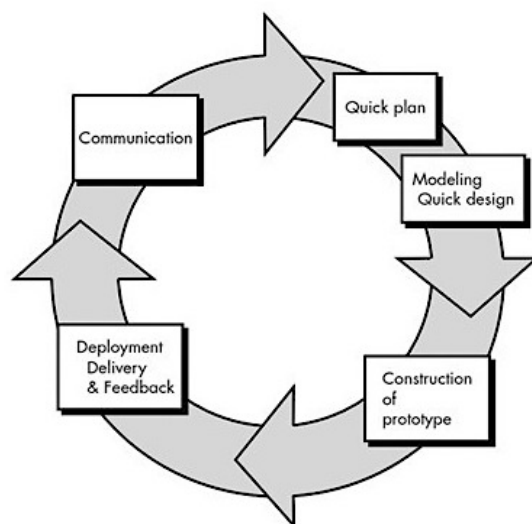


**Figure 3.** Prototype Model [36].

The functions of each button were programmed in the Adobe Animate Creative Cloud development environment, as well as each of the application modules, as shown in Figure 4.

The creation of the prototypes was very helpful as they served to assess whether children with dyslexia could interact with the application, whether that they would use it, and to show their successes with or doubts about its content, as well as how attractive or boring it seemed to them.

In Figure 5, the initial screen of the playful application is presented, showing four options of guided reading titles (represented by means of blocks), which were the final result of having designed the previous prototypes in order to obtain the approval of the children and teachers, who would be the ones to interact with this technological product.

In Figure 6, the screen is presented, showing the options "Reading" and "Exercises" of the topic "The eating spoon", in both contents. When chosen, they show a series of graphic elements, which the child discovers when interacting with them. In addition, complementary exercises are provided, which are related to the learning activities carried out in classes. In the "Exercises" option for each reading, there are three possibilities to choose from: "Order sentences", "Complete the words", and "Antonyms".
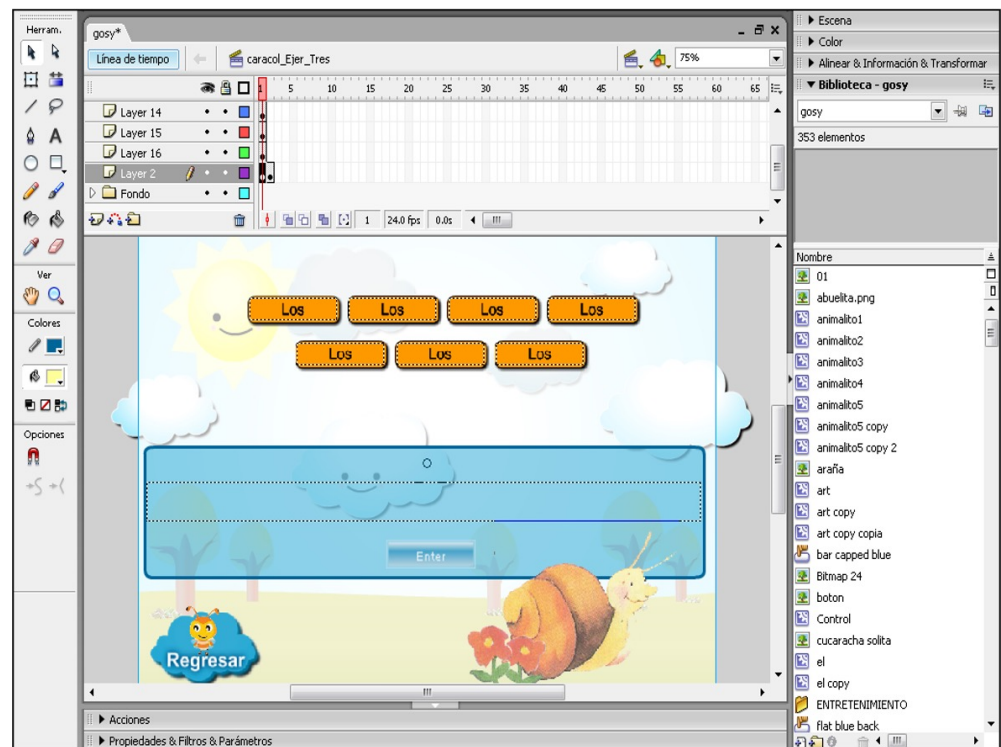
**Figure 4.** Example of prototype development in Adobe Animate Creative Cloud.



**Figure 5.** Initial screen of the playful application.

As a complement to these activities, children are given the option of interacting with the playful part of the application, offering them to choose any of the activities: "A new word", "Look for vowels", "In alphabetical order", "Do they start the same?", "Aquarium of colors", and "Crossword" (see Figure 7).

*5.5. Test or Evaluate Stage*

In this stage, the prototype developed was provided to the dyslexic children of the CRIE who then interacted with it, allowing them to observe and detect the failures and successes when navigating the various content screens of the application.

Table 7 shows the technique used to test the designed prototypes and to detect possible flaws in their content, structure, or operation.

**Figure 6.** Options for each guided reading.



**Figure 7.** Play activities of the application.

**Table 7.** Description of techniques used in the Test or Evaluate stage.

| Techniques Used for the Test Stage | |
|---|---|
| **Techniques** | **Description** |
| Usability test | The Usability Test allowed the children to interact with the application, carrying out the tasks that they normally do in the classroom with their teaching materials, but now in a virtual environment. Their opinions were collected through specific questions regarding the content (e.g., images, colors, sounds, texts), the friendliness of the information, and ease of use. |

The ISO 25000 standard of 2015 mentions that usability is the ability of a software product to be understood, learned, used, and be attractive to the user, when used under certain conditions [37].

The usability test that was carried out on the developed technological product was of a formative nature and was used to detect all aspects of the product that may generate problems for users, with the purpose of improving it. This involved qualitative aspects, such as satisfaction, fun, and perception of ease of use [38].

For this, the "Think aloud" technique was used, which is used in children to determine their behavior when using the product under evaluation [39]. This was applied by the teachers responsible for their process of learning, who took note as to whether they completed the tasks, if they performed them satisfactorily, the number of times they required help, as well as the comments they expressed about the playful application.

In Figure 8, the design of one of the tests that the children carried out and the opinion of the results, issued by one of the teachers in charge of the group, is presented.

| **Nombre:** Elegir actividad | | | **Caso de prueba:** PD-01 | |
|---|---|---|---|---|
| **Descripción:** El niño podrá elegir en la aplicación las actividades mostradas para la opción de "Entretenimiento". | | | | |
| **Prerrequisitos:**<br>• Abrir la aplicación con el icono establecido para esta.<br>• Seleccionar opción deseada<br>• Seleccionar actividad | | | | |
| **Pasos:**<br>• El usuario ingresa a la aplicación.<br>• Seleccionar opción correspondiente.<br>• Una vez dentro de una opción, podrá seleccionar cualquiera de las actividades. | | | | |
| **Resultado esperado:**<br>• Se mostrará la pantalla correspondiente a dicha actividad. | | | | |
| **Resultados** | | | | |
| **Excelente** | **Muy bien** | | **Bien** | **Regular** |
| **Comentarios:**<br>El niño interactuó "Muy bien", cumpliéndose los resultados esperados, ya que pudo ingresar a cualquiera de las actividades en cada una de las misiones correspondiente. | | | | |
| **Interfaz por usar:**<br><br>Del menú de la aplicación elegir las actividades de la opción de "Entretenimiento". | | | |  |

**Figure 8.** Example of a usability test design.

The prototype tests were very useful as they allowed us to determine the details that caused confusion in some of the contents, sounds that were not correctly reproduced, or the navigation and interactivity mode on the screens.

Once these aspects had been overcome, the development of the final application was carried out, which adhered to the steps of the design thinking methodology. It was installed on the computer equipment at the CRIE, such that the children could work with it as part of their didactic activities within the classroom, and so we could carry out a pilot study to evaluate their achievements before and after used of the designed application.

This made it possible to verify the academic performance that these children had achieved, by assessing their learning activities before and after using the application. For this, we reviewed the evaluations that their teachers had carried out with them.

It is important to mention that due to the characteristics of this type of population, data from their formative evaluation must be collected as it represents evidence of academic progress to overcome the deficiencies that these children present, compared to only collecting data from a summative evaluation.

The learning activities were designed to support the literacy of dyslexic children, involving topics such as ordering sentences, completing words, reading, and understanding texts, detecting the relevant ideas in a text, and phonological awareness (including spelling words, syllabic awareness, visual decoding, and synonyms and antonyms).

In Figure 9, the data for the topics that were taken as reference are presented, supporting the literacy of these children with activities within the classroom through their

traditional materials, as well as when making use of the playful application, noting that there was an increase in achievement with the use of the latter.

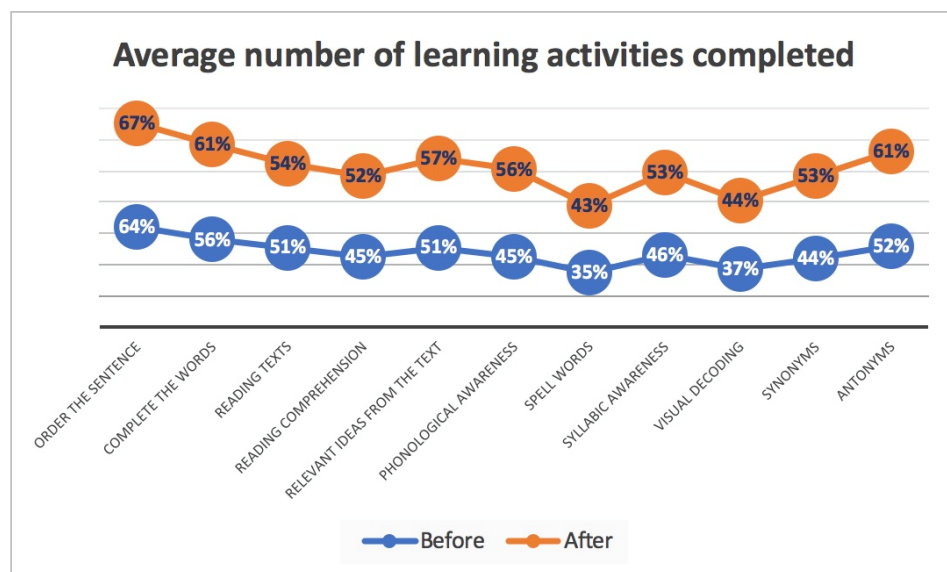**Average number of learning activities completed**

Figure 9. Average of activities solved by the children.

It was also found that, through use of the playful application, the average number of mistakes in the reading–writing activities assigned, which is normally reviewed in the classroom when using traditional didactic materials, decreased in all of the activities (see Figure 10).

**Average number of mistakes in activities**
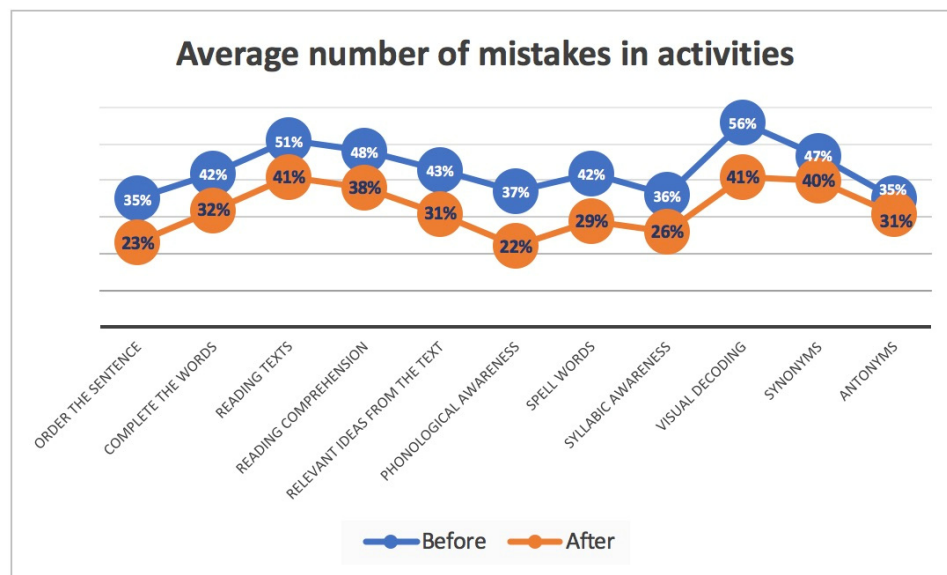
Figure 10. Decrease in mistakes in activities carried out by children.

## 6. Discussion

Using specific educational strategies, such as the playful application developed in this research work—for which ICT and the design thinking methodology were used—should support the achievement of better performance in the topics addressed in the classroom, contributing to an adequate school integration of children.

In general, all children need stimuli to promote their learning and enhance their cognitive, motor, and emotional abilities. Children with dyslexia often have learning

difficulties, as they confuse letters, sounds, and syllables, which poses challenges in reading, understanding, writing, and expressing themselves.

The design thinking methodology offers a solution to a given problem [40]; through dividing it into smaller parts, it can be analyzed and, in an empathic way, all the possible ideas that help to solve it can be considered. Following this, prototypes can be built and tested in the population who are expected to see benefits from the final solution.

Using the design thinking methodology (also known as design thinking), which is user-centric, helped us to understand the educational needs that children with dyslexia present during their daily classes, as we reviewed the various topics of their learning and solving the different learning activities. As a result, we developed a playful application that supports the academic achievement of these children with very particular cognitive characteristics.

The creation of the playful application allowed us to corroborate that the didactic game with a clearly defined objective and structure, according to the specific needs of the children, allows them to propose different tasks which help them develop their abilities and improve their academic performance.

The purpose of improving the academic performance of these children with dyslexia, through the use of this technological product, can be seen in the results presented in this document, with respect to the achievements obtained in the activities that the teachers assigned them in the classroom with their traditional materials whereby, after using the playful application, performance increases were noted in the sample population.

Similarities could be observed with respect to entrusted literacy activities which are normally reviewed in the classroom, where the average number of mistakes was decreased after use of the playful application.

## 7. Conclusions

The design thinking methodology, applied to the educational field, allows researchers to design solutions according to the needs of learners, as its central axis is the human being, while feeding on design tools that allow for the integration of educational needs with technological tools in order to present didactic solution prototypes that support the learning process.

Therefore, in this research, the design thinking methodology was used to develop a playful application that serves as a support for children with dyslexia at the Resource and Information Center for Educational Integration (CRIE), of the municipality of Centro in the State of Tabasco, Mexico.

People with a learning disorder, such as children with dyslexia, require educational attention, as they may present significant limitations in processing, retaining, retrieving, and consolidating the information they receive. Therefore, the information given to them must be specific content which is designed to help them overcome their difficulties in the educational environment.

The development of various prototypes, which were put to the test with the children, allowed us to identify details that were common knowledge for a technology developer but were not entirely clear to the children. These adjustments led to the development of a playful application, which they now use in the classroom as part of their teaching materials and which they can also use at home with the guidance of their parents.

It is worth mentioning that, with the playful application, it was possible to verify the benefits that these children experienced in their learning activities regarding the topics they review in the classroom: we noted an increase in the number of activities solved correctly as well as a decrease in the number of mistakes made in diverse categories.

With this playful application, our aim is to support the CRIE—and, specifically, children with dyslexia—in having didactic resources according to their needs which can be used as a didactic complement within the classroom while fundamentally contributing to the improvement of academic performance and achievement in subject areas that are reviewed daily in their academic context.

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