

<https://doi.org/10.23913/ride.v11i21.758>

*Artículos científicos*

## **La inclusión de niños sordos en educación básica en una escuela de México mediante el diseño de recursos digitales**

*Inclusive education for deaf children in a Mexican Elementary school through digital tools design*

*A inclusão de crianças surdas na educação básica em uma escola no México por meio do design de recursos digitais*

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### **Resumen**

La gran variedad de situaciones a las que se enfrentan las personas sordas desde el nacimiento las ha llevado a diferentes tipos de escolarización. El sistema educativo mexicano ha generado diversos procesos de inclusión educativa sustentados en los derechos de los individuos. Entre las ofertas educativas a nivel básico, en el estado de Querétaro, en la extensión del Instituto Queretano Marista (EIQM), se ha iniciado un estilo de inclusión a través de la lengua de señas mexicana (LSM) y la enseñanza de español.

El objetivo de esta investigación fue diseñar y aplicar una herramienta digital para la enseñanza del español de los alumnos sordos en educación básica. El trabajo se realizó en cuatro fases utilizando la investigación basada en el diseño (IBD). La primera fase estuvo enfocada al análisis de problemas, la segunda consistió en el desarrollo de soluciones e

innovaciones tecnológicas que pudieran favorecer la enseñanza de español, la tercera consistió en la aplicación de las soluciones de forma iterativa (es decir, a modo de prueba y error) y la última fase permitió enmarcar los principios de diseño acordes a las necesidades del alumnado. El desarrollo de los recursos digitales incluyó la realización de animaciones 2D, videos y juegos. El equipo de profesionales estuvo conformado por intérpretes educativos, personas sordas y profesores de grado.

Los primeros resultados obtenidos demuestran cómo las herramientas digitales son complementos que se aplican en el aula para favorecer los procesos de aprendizaje del alumnado sordo y un acompañamiento a profesores y tutores para la enseñanza de la lengua española. La investigación expone que las herramientas digitales basadas en el juego, recursos visuales y kinestésicos, así como la evaluación procesual favorecen la atención y la repetición para la comprensión de la segunda lengua en alumnos sordos. La investigación demuestra que no solo la tecnología, sino también la cultura pueden ofrecer oportunidades para el aprendizaje de las personas sordas.

**Palabras clave:** educación básica, inclusión, investigación basada en el diseño, niños sordos, recursos digitales.

### **Abstract**

The wide variety of life issues that deaf people face from birth has led them to different types of schooling. The Mexican Educational System has made different processes of inclusive education based on individuals' rights. Among the educational offerings at elementary school, in the State of Querétaro, specifically at the Extensión del Instituto Queretano Marista (EIQM), an inclusive education type has been introduced through the Mexican Sign Language (LSM) and the teaching of Spanish language.

The research objective was to design and apply a digital tool for teaching Spanish to deaf students in Elementary School. The research was conducted in four phases using Design Based Research (IBD). The first phase focused on problem analysis, the second phase consisted of developing solutions and technological innovations that could favor the teaching of Spanish, the third phase was based on the application of solutions in an iterative way, that is, on an experimental basis, the fourth phase allowed framing the design principles according to the needs of the students. The development of digital resources included making 2D

animations, videos, and games. The team of professionals included educational interpreters, deaf people and teachers.

Digital tools are not the whole of teaching, but a classroom complement and a supplement for teachers and tutors. The research shows that digital game-based tools, visual and kinesthetic resources, as well as procedural evaluation favor attention and repetition for the understanding of the second language in deaf students. Research shows that not only technology, but culture can expand learning opportunities for deaf people.

**Keywords:** elementary school, inclusive education, design based reseach, deaf children, digital tools.

## Resumo

A grande variedade de situações que os surdos enfrentam desde o nascimento os leva a diferentes tipos de escolaridade. O sistema educacional mexicano gerou diversos processos de inclusão educacional baseados nos direitos das pessoas. Entre as ofertas educacionais de nível básico, no estado de Querétaro, na extensão do Instituto Queretano Marista (EIQM), iniciou-se um estilo de inclusão por meio da língua de sinais mexicana (LSM) e do ensino do espanhol.

O objetivo desta pesquisa foi projetar e aplicar uma ferramenta digital para o ensino de espanhol para alunos surdos na educação básica. O trabalho foi realizado em quatro fases usando pesquisa baseada em design (IBD). A primeira fase foi focada na análise de problemas, a segunda consistiu no desenvolvimento de soluções e inovações tecnológicas que pudessem favorecer o ensino do espanhol, a terceira consistiu na aplicação das soluções de forma iterativa (ou seja, como um teste e erro) e a última fase permitiu enquadrar os princípios de design de acordo com as necessidades dos alunos. O desenvolvimento de recursos digitais incluiu a realização de animações 2D, vídeos e jogos. A equipe de profissionais era composta por intérpretes pedagógicos, surdos e professores universitários. Os primeiros resultados obtidos demonstram como as ferramentas digitais são complementos que se aplicam em sala de aula para favorecer os processos de aprendizagem de alunos surdos e apoiar professores e tutores para o ensino da língua espanhola. A pesquisa mostra que ferramentas digitais baseadas em recursos lúdicos, visuais e cinestésicos, bem como avaliação processual, favorecem a atenção e a repetição para a compreensão da segunda

língua em alunos surdos. A pesquisa mostra que não apenas a tecnologia, mas também a cultura podem fornecer oportunidades de aprendizagem para pessoas surdas.

**Palavras-chave:** educação básica, inclusão, pesquisa baseada em design, crianças surdas, recursos digitais.

**Fecha Recepción:** Mayo 2020

**Fecha Aceptación:** Octubre 2020

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## Introduction

Human interaction with the world begins from birth. The senses help discover smells, textures, tastes, colors, and sounds. The lack of any of these implies a limitation to discover the outside. The person declared deaf may (or may not) have hearing loss, have lost their hearing at some point in their life or have been born without the ability to hear. The family - depending on the knowledge they have on the subject, the advice from the various professionals, their economic, social and cultural position - will determine the time and type of schooling their children will receive: traditional schools, multiple care centers (CAM), inclusive schools or home schooling (Brunot, 2019; García, 2018; Romero and García, 2013). In Mexico, the Ministry of Public Education (SEP, 2015, 2016, 2017) has invited public and private institutions to generate educational processes that promote the inclusion of people with functional diversity. In this sense, the new guidelines point, on the one hand, towards a metamorphosis in the structures of the educational system, which seek to focus on the how, what and why of education, with emphasis on the fact that training is a key element not only for the students, but also for the teachers. And on the other, to generate inclusive practices on the part of the teachers of the "normalista" schools, promoting the participation and collaboration of the entire educational community. This seeks to understand that "diversity gives the opportunity to learn and teach with it, and guarantees access, permanence, participation and progress for all students" (Bonilla, Fernández and Vázquez, 2019, p. 5) . Having explained the above, it can be said that this research has been developed in the extension of the Queretano Marista Institute (EIQM), which has started an inclusion program, adopting as a position the existence of a community of deaf people, the acceptance of the language sign language (LSM) as a first language (L1), Spanish as a second language (L2) and the existence of a communication bridge between listeners (people who can hear) and the deaf (anyone with hearing functional diversity): LSM educational interpreters. For this,

from the perspective of research based on design (IBD), digital resources have been developed in order to favor and enhance the teaching of the second language: Spanish.

The significance of the research resided in the recognition of a group of people that has been classified in the field of disability, a politically accepted term in Mexico to refer to people with a different physical situation than usual, and not as individuals belonging to a cultural group that demands respect for their rights, cultural manifestations, spaces, as well as a way of learning, among others (Lissi, Svartholm and González, 2012; Moores, 1990). Consequently, the de facto urgency for society, through the search for resources and research, contributes to the creation of spaces and the development of resources and materials to promote the full development of all people. (Armstrong, Armstrong y Spandagou, 2010; García, 2018; Lankshear y Knobel, 2008).

For the development of the digital tool, effective techniques were distinguished for teaching Spanish (L2), which should favor face-to-face classes at school. To this end, various teaching strategies were analyzed, from the type of student received to the characteristics of the teachers who serve this group; to identify how the teaching techniques carried out for the teaching of deaf students allow the use of technology to support the instruction of an L2, as well as the appropriate spaces and times for the development of the tool and the achievement of the proposed objective.

### **The inclusion of the deaf community of Querétaro: from L1 to L2**

The deaf community of the state of Querétaro has deployed its own spaces for meeting and participation. In these, young people have focused their efforts to develop artistically in the field of illustration and painting, as well as in sports teams, especially in soccer, and as professionals in physical therapy, animation and administration. However, inclusion for deaf people has had various difficulties, such as the lack of training and awareness of teachers. Few people are interested in learning, applying and interpreting LSM, and consequently in communication.

From the inclusive approach, it is necessary for educational institutions, as stated by Booth and Ainscow (2002), to take into account three dimensions: inclusive cultures, inclusive policies and inclusive practices. In this way, inclusion is viewed as equal opportunities for all people, based on accessibility, seeking to break down all kinds of barriers based on inclusive and democratic models (Unicef, 2017).

The development of an L1 is essential for learning an L2 (Navarro, 2010). Deaf people are recognized for the development of LSM (L1), but not L2 (Spanish). The inclusion model implemented in the school has its *raison d'être* in the needs observed to promote the continuity of studies, so the teaching model of L2 and the reflection of the LSM were adopted as L1, encouraging At the end of basic education, deaf students take the corresponding certification exam and access subsequent academic degrees with the necessary and essential linguistic competencies to understand, analyze and question, where appropriate, the contents.

Communication is a skill that allows human beings to get involved, participate and interact in society from their first months of life; Likewise, it gives them the opportunity to understand their relationship with the environment in which they operate through fundamental processes that require perception, memory, categorization and information processing (Lieberman, Hatrak and Mayberry, 2014). This opportunity to learn a natural form of communication taking into account all the syntactic complexity is crucial for the development of the brain, the organization of ideas and, therefore, for the acquisition of other languages in the course of life (Skotara, Salden, Kügow, Hänel-Faulhaber and Röder, 2012). This form of natural communication can only be learned from the first years if it is accessible, interactive and abundant (Gertz and Boudreault, 2016). Thus, learning a language is an active process, in which its rules and concepts are discovered through creative manipulation and hypothesis testing. The diversity of linguistic experience in terms of receiving information and expressing it is necessary for the acquisition and development of language. A child is an active agent in her own language development (Brennan, 1975).

The foregoing invites questions in the field of education such as the following: is it being achieved that deaf people acquire a language that allows them to have access to their cognitive development? Approximately 90% of deaf infants are born to hearing parents (Cole and Flexer, 2019; Mitchell, 2004; Moores, 1990), which implies new challenges in the process of teaching a language: the first is how to make a person who does not listen understand or understand what is being expressed; the second, what to do to minimize the problem, to which specialists or institutions to turn to joint efforts and processes.

According to studies conducted by Goldin-Meadow and Mayberry (2001), if deaf infants are born into families where the parents are hearing, intervention is needed in a variety of ways. The early detection of hearing loss must be accompanied by prompt entry into an educational system where LSM is taught and be in contact with people who speak it fluently, that is,

ensure that the deaf infant has access to the language of signs since childhood (Hurford, 1991; Stokoe, 2005). On the other hand, Susskind and Susskind (2017) explain that at the age of three and a half years the human brain has completed 85% of its growth, so these first years of life are crucial in the development of the language. Thus, a deaf person who does not have access to language in the first years of life will be semilingual. The term semilingualism is used, as explained by Fridman (2009), to explain that a person can speak two languages, but does not fully master them, that is, the command of one language is greater than the other. In this case, deaf people have a greater command of LSM than of the Spanish language.

The acquisition of the LSM, like L1, allows deaf students to communicate effectively with each other, enabling a collective conversation between teacher and students to take place in the classroom, and not just a one-to-one dialogue between student and teacher. This fluency in communication, favored with an LSM educational interpreter in the classroom, also allows the realization of collaborative work activities, which in turn enhance not only the learning of the contents, but also the linguistic development of L1 and L2, given that students present different levels of performance in both languages (Lissi, Svartholm y González, 2012).

It is important to note that the LSM is not a translation from Spanish and that it is also graphic, so the use of on-screen captioning technology does not resolve the fluency of communication within the classroom. For this reason, mastery of the LSM by the student is essential to understand the teacher through the educational interpreter.

All these factors are determining factors in deciding how L2 will be taught in an inclusive environment. One of the conditions for starting the inclusion process - in addition to the acceptance of the LSM as L1 - is the adoption of the LSM as part of a school-wide cultural process, that is, as an extra subject for groups in which that there are deaf infants.

Regarding the learning of languages in the curriculum, there is a difference between hearing and deaf as shown in the table of language classes for the deaf and hearing.

**Tabla 1.** Clases de lenguas para sordos y oyentes

	<b>Lengua materna</b>	<b>Lengua extranjera</b>
<b>Oyentes</b>	Reflexión de la lengua española	Aprendizaje de la lengua inglesa
<b>Sordos</b>	Reflexión de la lengua de señas	Aprendizaje de la lengua española

Fuente: Elaboración propia

Among the challenges that are presented for the education and instruction of deaf people is the lack of standardization of the LSM, that is, there are few studies on it, and those who use it generally learn empirically when approaching deaf communities. This is not a limitation, although it is easier to teach an L2 if you have reflected on the structure of the L1.

Bilingual bicultural education accepts the use of two languages in a differentiated way, that is, the teacher speaking Spanish while an educational interpreter transmits the information in LSM. Thanks to this education it is possible to promote the development of the LSM as L1 and in turn use it to facilitate the learning of written Spanish. This type of education needs an environment in which the training of hearing and deaf teachers is emphasized - in addition to LSM - so that students become competent users of both languages (Lissi, Svartholm and González, 2012), since in the more proficient your language, the easier it will be to introduce L2.

In order to teach an L2 to people with hearing functional diversity, within the present investigation, conditions to solve were determined, such as the foundations of an L1 and the procedures to simultaneously carry out academic teaching in their L2.

### **Research context**

The research was developed in the extension of the Queretano Marista Institute (EIQM), an institution that seeks to educate children and young people from a humanized and personal education (Ruiz de Chávez et al., 2013) that responds to people with disabilities, designing and creating provincial programs, including the so-called Special Marist Group (GEM). This seeks to help students to their personal maturity, achieve their independence, recognize their dignity, as well as provide spaces to socialize and feel accepted. In addition, this institution also planned its own inclusion system for deaf students and made it available for this research project.

The inclusion system seeks that deaf people naturally acquire the LSM and from this they learn the L2, all this through the work of undergraduate teachers and workshops, and the educational interpreters of LSM. The objective is to ensure that children can be included with their interpreter in a regular group from third or fourth grade.

The project for deaf students is not a provincial program; However, the experience observed with the GEM groups and the work carried out at the Marista University, Mexico City campus, which has already served a person deaf from birth, graduated in 2013 as a



psychologist, speaks of a verifiable experience that contributes in much to the research project.

This new project has been supported with a digital tool. Technology has proven useful in making literacy processes efficient. Learning environments are favored by their use, in an accessible way, stimulating creativity and innovation in users. Students can discuss their ideas throughout the writing process through synchronous and asynchronous ways. An important aspect of digital literacy is that it enables both students and teachers to use different media (Lankshear and Knobel, 2008).

Digital environments can promote the academic instruction of deaf students in the classroom, making possible the processing of texts, group conferences, sending and receiving e-mail, data storage and analysis (Cacheiro, Sánchez and González, 2016; Martínez, Gutiérrez and Fernández, 2018). Technology allows students and teachers to share thoughts and ideas expressed in text.

## Methodology

The present work was qualitative in nature and the technique used was design-based research (IBD). The objective of this was to design and apply a digital tool for the teaching of Spanish to deaf students in basic education of the EIQM. By virtue of the conditions in which this type of research is used, it should allow the inclusive project to be carried out from the first grade of primary school and access to make changes in the process, based on the fact that the IBD intends to solve a practical problem and complex. Research is described as adaptive, collaborative, contextual, flexible, goal-oriented, grounded, integrative, interactive, interventionist, methodologically inclusive, multilevel, pragmatic, process-focused, theoretical, transformative, and utility-oriented (Cobb, Confrey, DiSessa, Lehrer, and Schauble, 2003; Gros, 2007; Kelly, 2003; McKenney and Reeves, 2012; Mckenney, van den Akker and Nieveen, 2006; Wang and Hannafin, 2005). This type of research can result in theoretical or practical contributions to be replicated in different contexts.

The techniques for obtaining the data were the semi-structured interview, participant observation and documentary analysis. The information was examined qualitatively, analyzing content, analytical induction and its triangulation. For the interviews, a specific script (Bisquerra, 2016) was used to identify the relevant information. The interviews were applied to teachers, parents, and new deaf students.

Likewise, the model proposed by Reeves (2006) was used to implement the IBD (Table 2), considering the technological scope of the research.

**Tabla 2.** Fases de la IBD

FASE 1	FASE 2	FASE 3	FASE 4
Análisis de problemas prácticos a través de investigadores y practicantes en colaboración.	Desarrollo de soluciones basadas en los principios de diseño existentes y las innovaciones tecnológicas.	Ciclos iterativos de pruebas y mejoras de soluciones en la práctica.	Reflexión para desarrollar los principios de diseño y mejorar la implementación de la solución.
Refinamiento de problemas, soluciones, métodos y diseño de principios.			

Fuente: Reeves (2006, p. 59)

According to the IBD approach, different implications can be observed both in the design and in the exploration of educational innovations. At the same time, it also requires a didactic involvement, in this case of teachers and interpreters; organizational, the involvement of management and the improvement of pedagogical approaches; and the possible resources, including digital ones, as nuclei of these innovations and consequently contributing to a better understanding of the nature and conditions of learning (Bell, Hoadley and Linn, 2004; Gibelli, 2014).

Table 3 shows the different phases of the research with their corresponding participants and activities.

**Tabla 3.** Fases de la IBD de la investigación

FASES	Descripción	Participantes	Actividades
<b>Fase 1</b>	Análisis del problema.	Investigador, padres de familia, profesores, intérpretes, alumnado	Entrevistas semiestructuradas, observación no participante y pruebas diagnóstica de habilidades cognitivas.
<b>Fase 2</b>	Desarrollo de herramientas digitales.	Investigador y profesionales.	Trabajo con expertos, revisión de de herramientas educativas, búsqueda de tecnología accesible. Desarrollo de herramienta.
<b>Fase 3</b>	Evaluación de soluciones sobre la marcha.	Con los involucrados y estudiantes sordos. Evaluación de los expertos.	Iteraciones con la herramienta, revisión de resultados.
<b>Fase 4</b>	Documentación y reflexión para introducir los principios de diseño	Investigador y profesionales.	Elaboración de principios para el diseño de la herramienta, mejora de soluciones e implementación.

Fuente: Elaboración propia

In phase 1, the semi-structured interviews with parents allowed to know a) the academic origin of the children; b) the family situation of the students; c) the academic perspectives of parents on their children; d) the education of the family members, and e) other relevant aspects.

**Tabla 4.** Participantes

Participante	GÉNERO	EDAD	USUARIO DE LSM
Infante sordo	M	8	Sí
Infante sordo	F	8	Sí
Infante sordo	F	8	Sí
Infante sordo	F	8	Sí
Infante sordo	F	7	Sí
Infante sordo	M	7	Sí
Infante sordo	M	7	Sí
Infante sordo	M	7	Sí
Adulto padre familia	F	42	No
Adulto padre familia	F	38	Sí
Adulto padre familia	M	36	No
Adulto padre familia	M	34	No
Adulto padre familia	F	38	No
Intérprete	F	45	No
Intérprete	F	36	No
Administrativo	F	55	No
Administrativo	F	42	No

Fuente: Elaboración propia

Regarding the interviews with interpreters and school administration, it was possible to know a) the academic level with which the children were received; b) learning expectations; c) the learning needs, and d) the model of inclusion carried out in the school.

The second phase was aimed at developing informed solutions through existing design principles and technological innovations. For the development of this phase, it was necessary to know the Marist Educational Model (MEM), which contains elements of instructional design, determination of the curriculum for teaching Spanish as L2 and the materials oriented to it, as well as the expectations of the interpreters and teachers. The MEM specifies that its planning pattern focuses on the student's sociocognitive development. Regarding the instructional design, the literature on the teaching of Spanish as L2 and its limitations for deaf students was examined. The school was assisted in the search for a text that would accompany the students in the expected learning from the first to the sixth grade of primary school, and the expected standards were developed with them based on the Common European Framework of Reference for Languages (CEFR) , in the adjustment of the learning indicated in the MEM, as well as in the didactic planning model (table 5) (Ruiz de Chávez *et al.*, 2016).

**Tabla 5.** Modelo de planeación corta del modelo

<b>Etapa</b>		<b>Actividades como proceso de aprendizaje</b> <b>Destreza + contenido + técnica de aprendizaje + actitud</b> <b>d + c + t + a</b>
Capacidades-destrezas		
Contexto	Inicio	Actividad 1: d+c+t+a
	Desarrollo	Actividad 2: d+c+t+a Actividad n: d+c+t+a
	Cierre	Actividad n: d+c+t+a
	MSA	Actividad n: d+c+t+a

Fuente: Ruiz de Chávez *et al.* (2016)

Based on this model, plans were made by thematic unit. Table 6 shows the format used for each unit. Each planning must show the capacities-skills, values-attitudes, as well as the contents and learning techniques.

**Tabla 6.** Planeación con el modelo

Asignatura:				Docente:			
Bimestre		Grupo		Ciclo escolar		Fecha:	
Bloque o unidad							
Aprendizaje esperado							
<b>Actividades como proceso de aprendizajes</b>						<b>Productos</b>	
Destreza/ contenido/ técnica de aprendizaje / actitud							
Inicio: Es una introducción realizada con dibujos animados.						Animación 2D, genera en los alumnos discusión sobre lo que sucede en la animación y se rescata vocabulario.	
Desarrollo: Video con la profesora intérprete explicando el aprendizaje esperado, acompañado de ejercicios extra que se realizan en línea.						Ejercicios en línea.	
Cierre: Se retoma video de la profesora y evaluación de habilidades						Autoevaluación en línea.	

Fuente: Elaboración propia

At the beginning of each session a 2D video can be viewed. For the elaboration of these, the list of the new vocabulary was given to a deaf cartoonist, based on her experiences, and taking into account the objective of the investigation, she created the plot of each one so that the contents were relevant for the students. The animations are a sequence of stories where the main character is a deaf girl who has just joined the school. The cartoons do not have audio and the characters show a table to communicate in writing. The animations are shown in figure 1.

**Figura 1.** Animaciones 2D para introducir cada tema

**Animación**

**¿Qué introduce?**

**ANIMACIÓN 1**



Animación de bienvenida. Narra la llegada de Camila a la escuela, su primer encuentro con los compañeros y la forma en la que es recibida. Se muestra su frustración cuando Juana, una compañera empieza a hablarle y no entiende nada, por lo que inician a hablar a través de un pizarrón utilizando español.

**ANIMACIÓN 2**



Se introduce los saludos. La amiga de Camila le presenta a un nuevo compañero que se asusta al ver que no lo escucha, así que inicia la plática a través del pizarrón y a partir de ahí inicia una gran amistad que los marcará en las siguientes aventuras.

**ANIMACIÓN 3**



El cumpleaños de Juana. Juana, la amiga de Camila celebrará su cumpleaños y la invita a su casa. Durante el festejo juegan y rompen la piñata. En la animación se observan fotos que se han ido tomando durante el festejo, haciendo alusión a vocabulario como: pastel, piñata, cumpleaños, etc.

Fuente: Elaboración propia

After each introductory screening, activities created by the researcher were carried out with different digital tools (Flippity, Ardora, Classtools). To this end, the teachers were asked to work with the aforementioned activities, supporting the students in case concerns arose. Links or links to activities were provided through Google Pages.

At the beginning and end of the activities, the students had access to a video where the interpreter explained the topics in LSM. As the subject progressed, each student could know their progress and close with a question form sent to the teacher's email.

The third phase consisted of iterative cycles to test and debug the solutions in practice. It is important to highlight that each unit represented an iteration, that is, the repetition of the teaching process reflected in learning units, which allowed perfecting the type of activities developed. In each of the iterations the theme was planned, developed both at the school and on the platform, the use of activities on the platform was evaluated and a new iteration was started.

Finally, the fourth phase was dedicated to reflection on the design and improvement of the implementation of the solutions. To implement the teaching of Spanish, the hypothesis known as Sapir-Whorf was considered; According to this, the language used by a person influences their interpretation of the world and, therefore, their behavior (Zamudio Mesa, 2010), hence one of the biggest concerns is the absence of spelling in the LSM, therefore that

this would be a first for the student. The use of videos with LSM accompanied by Spanish subtitles served this purpose.

## Results

The inclusion observed in the group in general was a positive experience, since the deaf students, as well as the hearing students, interacted naturally during breaks without the need for an interpreter. The use of technological tools favored the learning of the second language and the written interaction, especially with teachers, because the rest of the hearing students became familiar with the use of LSM and a large part of the interaction between students was through signs.

During the first phase, differences were observed regarding the origin of the students. Those from another school in the public sector evidenced the use of basic signs and some invented or signaled, as well as incorrect manual configuration and greater use of signed Spanish. Also, and despite the use of spelling, the children did not know the order of the alphabet. Regarding the interaction with the environment, the students were unaware of the social norms and conventions in a school environment, that is, they did not know how to train, the order in class and the following of the instructions. Regarding the interaction with other colleagues, they were open but with difficulty in communication.

The students who had their first contact with a school were unaware of the LSM, as well as the images and gestures; however, a functional socialization was observed respecting the rules, following the instructions through imitation and being open to receiving new information. Regarding socialization, they had a good disposition, but equally difficult in communication.

The observations made show that although the children are cognitively capable of learning, at home the reinforcement on the topics is practically non-existent due to the communicational limitation. Therefore, one of the determining factors for the success of learning is found in the participation of parents.

On the other hand, semi-structured interviews were conducted to determine how inclusion in the school was happening. To analyze this information, the data were grouped into four recurring and interrelated themes:

- "Educational inclusion" (IE): Because the school has adopted an educational inclusion system, the theme of "deaf children with hearing", "children who do not hear who are in the classroom", "teachers that use their hands to say things ", "attention to all students ", and so on.
- The second category was focused on the concept of "deaf identity" (SI): The participants emphasized differences between deaf and hearing people: "the deaf", "sign language", "the interpreter", "the songs in Sign Language".
- The third category was determined as "class group dynamics" (DG): This is linked to the activities carried out as a group without differentiating whether they are deaf or hearing: "when we play", "we all participate", "nobody knows the answer ", "Help us ", etc.
- Finally, the fourth category "teacher-student-school-family relationships" (R): Some comments associated with this were: "my teachers help us", "the teacher tells us", "my son asks for help at home", "The teacher sends us messages", "we ask the teacher for information", etc.

During phase 3, greater difficulty was observed in the use of the tools in the parents. The students had no problems as long as they met their teacher. Use at home was not successful as most of the students did not have access to an internet device.

During the first observation, they were allowed to search the page without giving any instructions. This created a lot of confusion for students to enter the page. In addition, their preferences for observing the most striking things were evident, so at first they skipped the videos.

In the second observation, an accompaniment was made during each activity. Preference was noted for the teachers' explanation videos and the welcome cartoon of each session. The story Camila wants a pet was very interesting for everyone and they felt identified with the situations represented. In general, there was no time to interact with all the tools.

The videos shown in the welcome of each unit were relevant to let the students know how to include themselves in groups of listeners. These videos also facilitated the introduction to the topics and favored the expected learning.

With the observations it was determined that the tool had some elements in which the student was autonomous, while in others they had to be directed by the teacher.



Regarding the use of the digital tool at home, there were difficulties, especially due to the socioeconomic status of some families, which did not have a computer at home or the Internet. For this reason, spaces were provided in the computer center with students and their tutors.

## Discussion

During the exploration phase and the bibliography review process, the main ideas of this research were forged. Different L2 teaching methods were analyzed (Lankshear and Knobel, 2008; Lissi, Svartholm and González, 2012; Navarro, 2010) for deaf students and their concordance with the MEM. In this sense, it was appreciated that the fundamental discrepancy lies in the form of communication, and not in the techniques or methods. However, a preference was identified to teach Spanish to deaf people based on the oralist approach, as well as on the bilingual-bicultural one, which are antagonistic, since the first is regenerative medical and the second is based on belonging to a culture ( Cole and Flexer, 2019; Goldin-Meadow and Mayberry, 2001; Lissi, Svartholm and González, 2012). A bimodal approach was also observed, most used in European countries, which combines the use of the voice and the LSM (Alcina Madueño, 2015, Sepúlveda, 2008). The presented design was based on the bilingual-bicultural approach.

On the other hand, deaf students were cognitively assessed with their hearing peers, and no fundamental contrasts were observed in their ability to learn. However, some research (Goldin Meadow and Mayberry, 2001; Hurford, 1991; Lieberman, Hatrak and Mayberry, 2014) on the learning of deaf people has established that the same hemispheres used by hearing people when language is processed are activated in deaf people when they use graphical representation and LSM.

Currently, although international, national and local policies were taken into account (Brunot, 2019; García, 2018; Sánchez Regalado, 2012; SEP, 2017, 2018) that allow the opening of educational spaces such as the one carried out in the research , it is noted that the official declaration that deaf people can receive education in their own language is still necessary. This would force our educational system to adjust the texts to the LSM or to hire LSM educational interpreters, for whom the preparation is still incipient. Meanwhile, the use of information technologies to improve the education of deaf people in an L2 may be a first effort to offer more educational spaces in a less expensive way.

As in the state of Querétaro there is no other basic-level school with the proposed bilingual-bicultural model, its selection consisted primarily of acceptance of the model, which is expensive because it requires - in addition to the teacher - the hiring of an educational interpreter of LSM by grade. We consider it of great importance to explain the educational function from the Marist framework, which in terms of the project of deaf people does not have an economic claim, but a foundation supported by their ideology and religious bases that proclaim mercy and the charism to listen to children and young people, especially the most disadvantaged.

The determination of the design principles of a digital tool for teaching Spanish such as L2 can be applied in any other subject, taking into account that the LSM will always play a fundamental role for teaching accompanied by Spanish (Cobb et al., 2003 ; Kelly, 2003; Wang and Hannafin, 2005).

The digital environment that houses different technological tools, as mentioned by Fontán (2004), is very broad, so that the group teacher is no longer solely responsible for the learning environment, but other agents, such as principals, come into action. families, professionals and deaf people themselves from their experiences. Consequently, educational technology can be a powerful tool to improve student learning outcomes (Cacheiro et al., 2016; Martínez et al., 2018). This can help teachers to broaden students' horizons and allow them to explore the limits of their freedom. In the same way you can add value to the lesson.

Regarding the families, they showed interest in knowing the tool, although it is worth noting that most have difficulty using computers with their children, since in general the students come from homes whose parents studied up to the high school level.

For the children, the use of technologies for learning was striking, especially because they saw their stories captured in the tool and they felt identified especially in the story and in the animated cartoon.

It can be said that the use of technology is accepted as long as the tool is at hand, the games are interesting and do not represent an impossible challenge for students.

## Conclusions

To create a digital tool aimed at deaf students, activities should be based on play and self-assessment, which should be developed as each activity is performed, without sacrificing the playful part. In this sense, the use of digital tools for teaching Spanish such as L2 to deaf children turns out to be an option to complement the learning seen in the classroom. However, it must be understood that deaf children develop language late, and that their L1, being greyish, constitutes a challenge for the teaching of L1.

To address this situation, online games promise to generate a hobby in children when the objectives are achievable and fun; therefore, the accompaniment of these students (either by the teacher or their parents) helps to determine if the activity met the objective. When developing digital content, it is necessary to consider who it is aimed at and what are the characteristics of the students; think in their globality, design them as a resource integrated into a learning process that covers other topics. In short, you must act with a lot of didactics for children to be able to understand, reason and carry out what you are trying to convey. Therefore, the material for minors must be easy to understand, with clear objectives, fun and visual. Exposing students to Spanish very early is the ideal due to brain plasticity that diminishes over time.

It should also be borne in mind that there is no perfect method to teach a deaf student, although visual and kinesthetic resources should be considered primarily when learning, knowing that in certain cases these could even represent a “noise” that would interrupt the learning.

Another determinant when it comes to learning an L2 is that it has a solid base in the L1, that is, the individuals who have better skills in the LSM have a greater chance of not getting confused when they learn Spanish.

Learning is more meaningful when it is culturally relevant. This means that when deaf students feel that they are members of a deaf community, the elements that are integrated into teaching from their community will be more likely to be learned.

On the other hand, it should be foreseen that the acts of reading and writing require different simultaneous processes. When you read, you must decode the words and understand what they mean. For deaf people, conjunctions, nexuses, articles, among others, are non-existent in their LSM dialogue. All of the above represents a great challenge when it comes to teaching. Therefore, technology is not and will never be by itself an infallible solution for the

teaching of the language or any other subject. While it is true that technology accompanied by good educational design can greatly benefit the teaching of L2, it is not the only thing to use.

It is a fact that deaf students feel part of the school community; However, it is also logical that they prefer to meet with their deaf peers due to the better communication they can establish with them, although as they advance in grade in school, more inclusion with others is observed, especially during recesses.

Therefore, if it is possible to establish a more natural school environment for them, there will be better possibilities for their inclusion to be successful. The fact is in understanding that being we are all different, we accept ourselves with our virtues and imperfections.

Finally, the next step in the research is to carry out the inclusion process in all school grades, which implies managing financial resources for the following productions, involving all teachers and associating with different interested institutions.

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