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Artículos científicos

La lengua de señas: una alternativa para mitigar los contagios de covid-19 en niños de primaria

Sign language: an alternative to mitigate COVID-19 infections in primary school children

Linguagem gestual: uma alternativa para mitigar as infeções por COVID-19 em crianças do ensino primário

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Resumen

La lengua de señas, al permitir la comunicación de forma no verbal, puede ayudar a reducir el riesgo de contagio por covid-19 entre alumnos y profesores dentro de las aulas. Desafortunadamente, ellos no están familiarizados con su uso y aunque existen sistemas de *software* que ayudan a aprenderlo, su principal inconveniente es que no evalúan si la ejecución de la seña es correcta o no. Por lo tanto, el problema que se aborda en este trabajo es la falta de sistemas de *software* que permitan, por un lado, instruir a los niños de educación primaria sin discapacidad auditiva o del habla sobre las nociones básicas de la lengua de señas mexicana (LSM) tomando en cuenta su estilo de aprendizaje y, por otro, evaluar qué tan bien están realizando las señas que han aprendido. Para ello, se desarrolló un sistema de *software*, tanto web como móvil, que satisface ambas necesidades, es decir, instruye, considerando el estilo de aprendizaje, y evalúa, mediante el reconocimiento de la imagen de la seña realizada por el infante. La valoración hecha por un conjunto de niños mostró que es

factible usar este sistema para apoyar la instrucción y evaluación de las señas del alfabeto y los números del LSM, con las cuales es posible formar cualquier palabra/cifra, por lo que esta propuesta se constituye como una alternativa para mitigar los contagios de covid-19 en niños de primaria.

Palabras clave: Lenguaje de signos, covid-19, educación primaria, sistema de información, enseñanza.

Abstract

Sign language, by enabling non-verbal communication, can help reduce the risk of Covid-19 transmission between students and teachers in the classroom. Unfortunately, they are not familiar with its use and although there are software systems that help to learn it, their main drawback is that they do not assess whether the execution of the sign is correct or not. Therefore, the problem addressed in this work is the lack of software systems that allow, on the one hand, to instruct primary school children without hearing or speech disabilities on the basics of Mexican Sign Language (LSM) taking into account their learning style and, on the other hand, to evaluate how well they are performing the signs they have learned. For this purpose, a software system was developed, both web-based and mobile, which satisfies both needs, i.e. it instructs, taking into account the learning style, and evaluates, through the recognition of the image of the sign made by the child. The evaluation made by a group of children showed that it is feasible to use this system to support the instruction and evaluation of the alphabet signs and LSM numbers, with which it is possible to form any word/letter, so this proposal is an alternative to mitigate the contagion of Covid-19 in primary school children.

Keywords: Sign language, Covid-19, primary education, information system, teaching.

Resumo

A linguagem gestual, ao permitir a comunicação não verbal, pode ajudar a reduzir o risco de infeção por COVID-19 entre alunos/professores dentro das salas de aula. Infelizmente, eles não estão familiarizados com o seu uso e, embora existam sistemas de software que ajudam a aprendê-lo, sua principal desvantagem é que eles não avaliam se a execução do sinal está correta ou não.

Portanto, o problema abordado neste artigo é a falta de sistemas de software que permitam, por um lado, instruir crianças do ensino primário sem deficiência auditiva ou de fala sobre as noções básicas da Língua Mexicana de Sinais (LSM), levando em conta seu estilo de aprendizagem, e, por outro, Avalie o quão bem eles estão executando os sinais que aprenderam. Para resolver isso, foi desenvolvido um sistema de software, tanto Web quanto mobile, que satisfaz ambas as necessidades, ou seja, instrui, considerando o estilo de aprendizagem, e avalia, através do reconhecimento da imagem do sinal feito pela criança. A avaliação feita por um grupo de crianças mostrou que é viável utilizar este sistema para apoiar a instrução e avaliação dos sinais do alfabeto e dos números do LSM, com os quais é possível formar qualquer palavra/figura, pelo que esta proposta se constitui como uma alternativa para mitigar as infeções por COVID-19 em crianças do ensino básico.

Palavras-chave: Linguagem gestual, COVID-19, ensino primário, sistema de informação, ensino.

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Introduction

The topics presented below serve to demonstrate the problem considered in this work. The description of these exposes the basic concepts that are related to the usefulness of the use of sign language as an alternative form of communication to mitigate covid-19 infections in primary school children and allow the reader to appreciate the way that addresses the solution to the problem.

Sign Language

Communicating is an essential aspect of being human. Since ancient times, people have tried to express their emotions, needs, desires, etc., through different means (Magnani, 2008; Williams, 1992). Although it is true that oral language is the most common form of interaction, non-verbal communication remains essential for individuals who suffer from some degree of hearing or speech disability, since this condition prevents them from expressing themselves through their voice (Schlesinger and Namir , 2014). In Mexico, according to the 2020 Population and Housing Census (National Institute of Statistics, Geography and Informatics [INEGI], 2020), 4.9% of the total population, that is, around 6,179,890 people, suffer from some type of disability. Of them, 22% have trouble hearing and 15% have limitations in speaking or cannot speak in an understandable way. This

involves the use of special communication techniques, for example, speech reading or sign language, for the integration of these sectors into society.

Sign language uses hand and body movements in general to facilitate dialogue (Schlesinger and Namir, 2014; World Federation of the Deaf , September 19, 2021). Although some of these movements or signals are universal, this form of communication is adjusted to each country, even to different regions within each of them. In Mexico, Mexican Sign Language (LSM)—which has its own syntax, grammar, and lexicon (De Fleischmann, 2015)—is officially recognized as a national language in article 14 of the General Law for the Inclusion of Persons with Disabilities. Disability (Official Gazette of the Federation [DOF], 2011) and as linguistic heritage in article 8 of the Constitution of Mexico City (Political Constitution of Mexico City, 2011).

Within the LSM, signs are divided into four different types, namely manual, bimanual, symmetrical and compound (Escobedo Delgado, 2017; Lengua de Señas Mexicana [LSM], 2016). In the first, only one hand is used. In the second, both hands are used either in a disparate, free or asymmetric way. The third also uses both hands, but the movements are mirror or inversely proportional. Finally, in the fourth, at least two simple signs or three different configurations are used. The signs in the LSM can be static, that is, they remain immovable during their execution, or dynamic, that is, they follow a trajectory that indicates the direction of movement.

Among the static signs are the letters of the alphabet, with the exception of J, K Ñ, Q, X and Z, which require some type of movement, and the natural numbers from one to nine. Through fingerspelling, which is the manual representation of the letters of the written alphabet, it is possible to construct any word/figure letter by letter/digit by digit, so that the exchange of information is possible at a basic level. The knowledge and mastery of these signs by the general population is particularly important because it can be used as an alternative form of useful communication in the time of the pandemic caused by covid-19.

Covid-19

At the end of 2019, the SARS-CoV-2 virus, which causes the covid-19 disease, appeared in the province of Wuhan, China. The World Health Organization (WHO) (2020), on March 11, 2020, declared it a pandemic, given the number of countries affected and the number of infected people around the world.

Research carried out on the virus indicated that the main means of transmission was the tiny liquid material that an infected person expelled through the mouth and/or nose when they coughed, sneezed, spoke or breathed, as it could become suspended in the air and travel distances. short - generally less than one meter - and/or come into contact, direct or indirect, with the eyes, nose and mouth of healthy people.

Among the recommendations to reduce the risk of contagion were the following: 1) keep a healthy distance of at least one meter between people, 2) use a sanitary face mask, 3) wash or disinfect hands frequently, 4) cover nose and mouth when coughing or sneezing, 5) avoid prolonged contact between individuals, crowded and/or poorly ventilated places, touching surfaces in public places, and, 6) get vaccinated (Guidance for the public, 2019). Taking the situation into account, several governments around the world, including Mexico, applied home confinements to their citizens with the purpose of containing the advance of the pandemic (Stay at home, 2019).

During some periods, work and academic activities were carried out from home and only essential activities such as health services continued to function. However, this measure was not long-lasting because other aspects of individual and social well-being such as mental health and economic condition could be compromised. In this way, the reopening of daily activities implied a new risk of contagion if prevention measures were not adequately followed. In this sense, one of the sectors that tried to provide the most appropriate environment possible for their return was education, especially at the levels that involved the youngest children, because although the data showed that in children under At eighteen years old, the disease manifested itself in a mild form and a relatively low number of deaths was recorded compared to other age groups; there were cases of critically ill patients. Therefore, it should be a priority to comply with health protocols in order to guarantee the safe stay of children in schools (Guide for the responsible and orderly return to schools. School year 2021–2022, 2021).

Primary education

In Mexico, the General Education Law establishes that basic education is made up of three mandatory educational levels: preschool, primary and secondary (General Education Law, 2019). In basic education, among other aspects, the formal contents of the language are addressed , which makes it possible to acquire more knowledge. Reading and writing are transcendental learning because when reading, not only are symbols decoded and spelling

and grammar exercised, but these signs are interpreted, what they say is understood, and the message they want to convey is identified. On the other hand, when writing, the graphic representation of oral language expressions is recognized, as well as other important symbols (Lerner, 2021).

To teach reading and writing, different educational strategies are used, among them are the following methods (Estalayo , 2003): alphabetic (spelling), phonetic (phonic), syllabic, normal words, global, eclectic, among others. The alphabetic method consists of separately saying the letters of each syllable, the syllables of each word and then the entire word (Carpio Brenes, 2013). In the phonetic method, letter sounds are first learned and then combined with each other to form syllables, words, sentences, etc. In the syllabic method, words and complex structures are formed from the syllable as the basic unit of learning. In the normal word method, a word familiar to the child is chosen, which is associated with a figure to facilitate its understanding and retention. Subsequently, the word is written on the blackboard and the children copy it in their notebook to form new words and phrases through the analysis of its basic components of syllables and letters and using known sounds (Barbosa Heldt, 2004) . The global method acts in a reverse sense, that is, it starts from the words to reach their basic units such as letters, syllables and sounds. Finally, the eclectic method tries to combine the best of the available methods to form a new one to achieve better results in reading and writing. Regardless of the method chosen to develop reading and writing skills in children, it is important that the ability to relate a concept and its meaning to the letters that make it up is encouraged.

On the other hand, we must take into account that each child, and in general each person, learns in a different way, so it is useful to know their particular learning style, since this identifies how individuals perceive and process information to build your own learning. There are various ways in which the learning style can be classified (González Clavero, 2011; González- Peiteado , 2013), one of the most common is taking into account the representation system (Mera Constante and Amores Guevara, 2017).

According to this criterion, there are visual, auditory and kinesthetic (tactile) styles. The first describes people who learn best using diagrams, or some type of graphical tool, such as concept maps, cause -effect diagrams, organization charts, etc., to represent and process information. In the second, the voice and ears are used as the primary way of learning, that is, it depends on listening and speaking both internally and externally, for example, reading aloud, humming or listening to music while studying. Finally, the third requires

children's bodily experiences when touching and interacting with objects or materials available in the classrooms. Activities that favor this learning style are workshops and the creation of projects. Based on the identification of the learning style, strategies that favor the acquisition of knowledge by children can be incorporated into classrooms. Even using information and communication technologies (ICT), such strategies can be implemented in *software systems* .

Problem Statement

In Mexico, the formalization of oral and written communication begins when children address the area of Spanish in primary education. However, the social distancing measures imposed by the pandemic caused by the SARS-CoV-2 virus kept educational activities suspended, which in some way affected the academic development of the students. With the advancement of the vaccination program, it was possible to return to classrooms in person, respecting the health measures indicated by the health authorities. However, the probability of contagion was still latent due to the interaction that could exist between students and teachers, for example, when asking and answering questions, since the main form of contagion is through liquid particles that sick people can expel when talking, coughing or sneezing.

The risk of contracting the disease in classrooms could be decreased by using an alternative form of communication that does not involve verbal language, for example, sign language. Unfortunately, the population of hearing students and teachers is not familiar with it and although there are *software systems* for literacy for people with hearing or speech disabilities that could be used to instruct the population of hearing students and teachers about LSM, one of The drawbacks they present are that they do not evaluate whether the execution of the sign is correct or not, so the user does not have immediate feedback about the progress made.

Therefore, the problem addressed in this work is the lack of *software systems* that allow, on the one hand, to instruct primary school children without hearing or speech disabilities about the basic notions of the LSM, such as the letters of the alphabet and numbers, taking into account their learning style and, on the other hand, evaluating how well they are performing the signs they have learned.

State of the art

In recent years, systems have been developed for recognizing and teaching sign language signs. Regarding sign recognition, vision-based systems are the most used, since they use classifiers to process images and find key characteristics in them in order to recognize gestures (Bantupalli and Xie, 2018; Pérez et al . , 2017 , Jiménez *et al* ., 2017), and it has also been possible to analyze movements that involve some trajectory (Yan *et al* ., 2019). Likewise, using the Kinect device, sign language phrases have been recognized (García-Bautista *et al* ., 2017) , while other alternatives include the use of a special glove to translate sign language into text (Ocampo *et al.* ., 2020) or sensors integrated into wearable objects or directly into the body to classify signs (Kudrinko *et al* ., 2021).

Regarding the teaching of sign language, attempts have been made to integrate multimedia technology so that people with hearing and/or speech disabilities can use the written form of sign language (Myasoedova *et al* ., 2020) to know the states and capitals of Mexico (Estrada-Cota *et al* ., 2021), etc. In particular, mobile applications have been created that attempt to assist in the literacy of the population of people with hearing or speech disabilities.

The ALAS project (ALAS: Alfabetizar a Sordos, 2018) was developed by the Universidad Veracruzana as a tool so that the community of deaf people can learn to read and write in Spanish through multimedia material such as animations, photographs, videos, games, exercises and stories. Learning takes into account people's prior knowledge, interests and abilities, while self-assessment is carried out by relating images to words. In Signamy (Signamy - Apps on Google Play, 2019, Sign'n - Home, 2019) a virtual assistant is used and it is possible to zoom in, zoom out and/or rotate the image of the sign to better appreciate it . It can convert voice, text and web pages to LSM. Say it in signs (Dilo con Señas, 2016) has eighty-nine signs distributed in seven categories: one function to play by watching the video of the sign and relating it to the correct image and another to practice by watching the video of the sign for each image . MiutApp (MiutApp , 2019) allows hearing people to learn LSM through tutorials, and people with hearing or speech disabilities learn useful information for their daily lives. According to its creators, this application addresses learning by taking into account the vocabulary and grammatical structure of the language.

Learn signs: Mexican Sign Language (Learn signs: Mexican Sign Language - Apps on Google Play, 2018) allows you to practice more than one hundred and eighty words through games. Self-assessment is carried out by guessing the word that corresponds to the

sign. Talking Hands (Estrada-Cota *et al* ., 2020) teaches preschool children in the LMS through games. Kitsord (Kitsord , Learn Sign Language, 2021) teaches using photographs and videos. The content is divided into levels that can be unlocked as the learning progresses and the evaluations are accredited. This application allows you to study the sign language of countries such as Spain and Guatemala and American Sign Language. The DILSE (*Dictionary of Spanish Sign Language*) collects the words or expressions of the LSE along with photos and videos that show each sign and its definition. The user can save the addresses in which they are most interested to consult them quickly. Each day a sign is presented in order to learn new words (CNSE Foundation, 2020).

Spread Signs (*Sign Language Dictionary* , SpreadTheSign , 2019) contains more than 300,000 sign languages from countries such as the United States, Czech Republic, United Kingdom, India, Estonia, France, Germany, Austria, Iceland, Italy, Japan, etc. mention a few. Each sign has a word, an image and a video. Finally, LSApp (LSApp , 2019) is an application that uses an avatar that shows each sign step by step. Games are used to practice and evaluate learning.

Methods and materials

This section describes the method for solving the problem, as well as the materials used. Specifically, a descriptive methodology was used - in accordance with what was indicated by Hernández *et al* . (2014), since basic statistics are used to process the data.

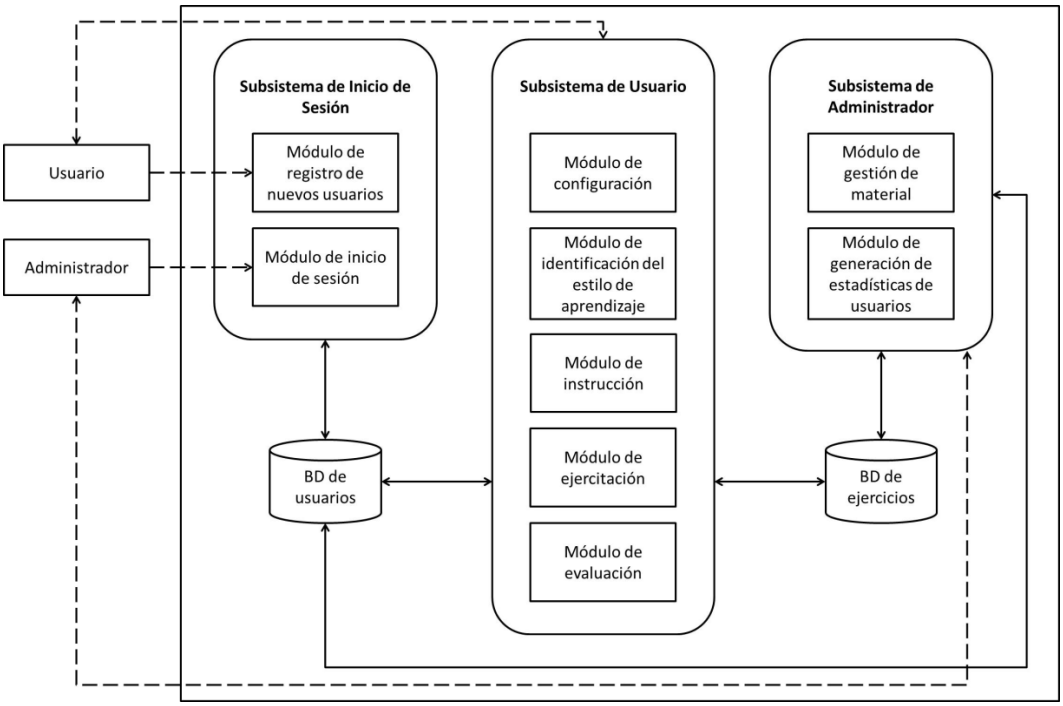
The solution proposal consisted of building a *software system* , both web and mobile, to instruct and evaluate primary school children with the ability to hear and express themselves in an understandable way using verbal language, on the signs that correspond to each of the letters of the alphabet and numbers so that, through manual spelling, they can express any word/figure and communicate without using oral language and without having to master the entire LSM. It is important to mention that spelling is not alien to the way hearing children learn, since it is a method used to teach them to read and write.

On the other hand, it is common for people with hearing or speech disabilities to use fingerspelling to express themselves (Herrera *et al* ., 2007), so the system is suitable for children with and without disabilities. To make the transmission of knowledge even more effective, the system considers the style that each child uses to learn, whether visual, auditory or kinesthetic.

Regarding evaluation, the scheme of relating signs to letters/numbers is used as a form of self-assessment; In addition, the sign that the child is making is examined in real time, through the analysis of images captured with the device's camera. This not only shows whether the child knows the sign or not (since he or she is only shown how to do it through images or videos), but it is actually evaluated by comparing it with images found in a database. . The latter is defined as a collection or repository of integrated data, stored on a secondary (non-volatile) medium and with controlled redundancy. Data that is to be shared by different users through applications must be kept independent of both the users themselves and their applications. The structure of a database is supported by a data model, which must make it possible to capture the interrelationships and restrictions that exist in the real world (Cattell *et al* ., 1997; Miguel and Piattini , 1999).

The system architecture includes three subsystems, with the modules shown in Figure 1.

Figure 1. System architecture



Source: self made

1. Login subsystem: Provides access to users. It consists of two main modules:
   1.1. Registration of new users, by filling out a form.
   1.2. Login, which gives access to the system to already registered users.

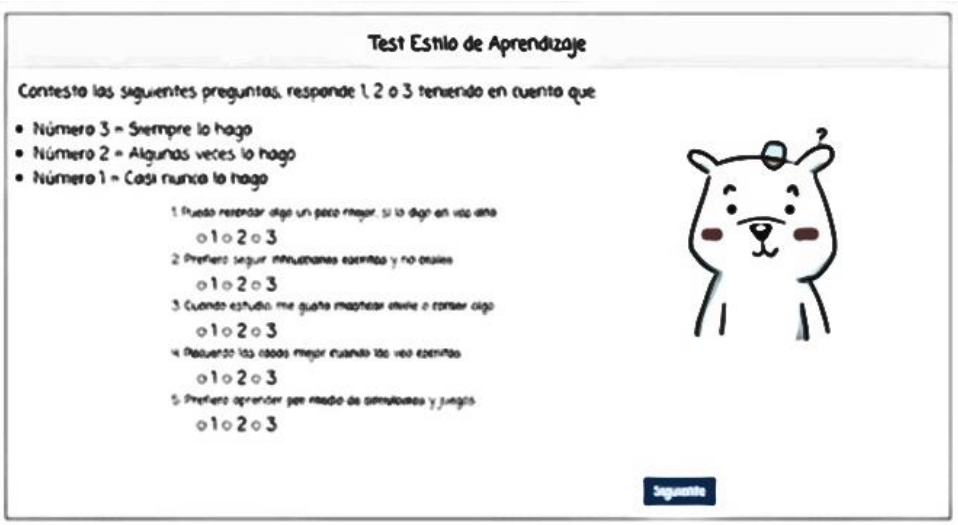
2. User subsystem: Serves users registered in the system. It is made up of five modules:
   2.1. Settings: allows the user to manage their account and select an interface of their choice.
   2.2. Identification of learning style: Identify the learning style of users by solving a questionnaire.
   2.3. Instruction: select and display content for each user, according to the previously identified learning style.
   2.4. Exercise: Present exercises to users so they can practice what they have learned.
   2.5. Evaluation: Assesses the skill acquired by users in the signs of the alphabet and numbers of the LSM through image recognition.
3. Administrator Subsystem: It is enabled for the system administrator to obtain information about the children's performance and update the exercises. It has two modules:
   3.1. Material management, which consists of incorporating, deleting and updating material.
   3.2. Generation of user statistics, which provides information about their performance.
4. The system contains the following two databases (DB):
   4.1. Users, which stores user data, including those generated by the evaluation module.
   4.2. Exercises, which saves the data of the exercises available in the system.

As it is a fundamental aspect of the developed proposal, the way in which the system instructs and evaluates sign language will be described in greater detail. This phase includes the programming of the system, so some of the interfaces are shown and what the user must do in it is explained.

Sign Language Instruction and Assessment

The first time the user accesses the system, they must take the test to determine their learning style, which consists of fifteen questions. That way you get personalized content. Figure 2 shows the question formulation screen.

Figure 2. Screen to identify learning style



Source: self made

Once the learning style is identified, the instruction of alphabet signs and numbers begins. For the visual learning style, the child is provided with instructions for signing, as well as an image of the sign. For the auditory learning style, audios are used that pronounce the rules to perform the sign in question. Finally, for kinesthetic instruction, analogies are used so that the user can, starting from some sign or gesture that he or she has previously used or seen, arrive at the one that is being shown. Figure 3 shows this type of instruction for letters.

Figure 3. Letter instruction in the kinesthetic learning style

Source: self made

To assess the child's skill in performing the different learned gestures, the system provides them with a word/figure so that they can build it letter by letter/digit by digit. For each symbol made, an image is captured and examined using the Tensor Flow tool. This, in turn, uses a convolutional neural network algorithm and an indicator is obtained of how well the sign is made. The process continues until there are no more symbols to form. In this way, the child has immediate feedback about the manual gesture he or she is performing. It is worth mentioning that to carry out this module, a recognition model was trained for each letter/number in which more than one hundred images with the specific sign were viewed.

Materials

In addition to the tests carried out on the system itself to verify that each programmed functionality was carried out correctly, validation was carried out with eight children between 8 and 12 years old. It is important to note that the sample consisted of eight children because, due to the social distancing conditions imposed by the pandemic caused by the SARS-CoV-2 virus, the space where the work was carried out only admitted ten people separated by one meter. distance between them, which were the students and the two instructors. We worked with the children for four days, an hour and a half per day, with two 5-minute breaks. All children had the endorsement of their guardians by signing a participation form. In addition, participants were asked to attend the validation of the system with a sanitary face mask, disinfect their hands with antibacterial gel before entering the application site and maintain a healthy distance between them. The tests were divided into three phases:

1. Collection of general information. The following data were obtained: full name, age, guardian's name, and type of personal device used (computer or cell phone).

2. General instruction. Instructions were given, step by step, on the use of the system; In addition, doubts were resolved and the participants interacted with the activities, as can be seen in Figure 4.

Figure 4. Users interacting with the system

Source: self made

3. Evaluation of user satisfaction. The execution of this phase allowed us to know the degree of satisfaction of the children with respect to their interaction with the system.

User satisfaction survey

This survey was conducted to evaluate interaction with the system. The responses obtained allowed us to identify those aspects that can be improved. For the application, the students were asked to read each of the statements carefully and mark with an "x" the option that best represented their level of agreement/disagreement with it. If in doubt, they could ask the instructor in charge. The question statement is in the first column and the answer options in the next four (table 1).

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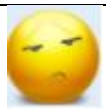
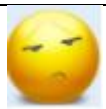
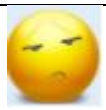
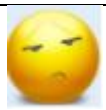
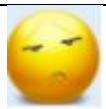
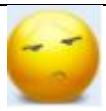
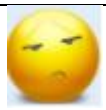
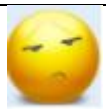
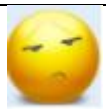
Table 1. Survey applied to the user

Statement	Strongly disagree	In disagreement	OK	Strongly agree
1. Overall, I am very satisfied with using this application.				
2. It was easy to learn how to use this app.				
3. I easily found the icons I needed to carry out my activity.				
4. The app shows error messages when I make a mistake.				
5. I easily performed the sequence of actions I was asked to perform.				
6. I understood what I was being asked to do in the application.				
7. The organization of the app's information on the screen was clear.				
8. I easily remember how to use this application.				
9. I liked using this app				

Source: self made

The survey in Table 1 was validated through Cronbach's alpha coefficient (Maese Núñez *et al* ., 2016), which measures the homogeneity of the questions by averaging the correlations between all the items. The closer the value obtained is to 1, the better the reliability. This characteristic is considered acceptable from a value of 0.70. Equation 1 describes the statistical formula for Cronbach's alpha coefficient and Table 2 shows the values obtained.

$$\alpha = \frac{K}{K-1}\left[1 - \frac{\sum S_i^2}{S_t^2}\right] (1)$$

Whence:

K: represents the number of items,

S_i^2: is the sum of the variances of the items.

S_t^2: is the variance of the sum of the items.

α: is Cronbach's alpha coefficient.

Table 2. Values to obtain Cronbach's alpha.

Element	Worth
K (total responses)	8
K – 1:	7
Sum of variances	5.964285714
Variance of sums	21.71428571
$\frac{k}{k-1}$:	1.142857143
$1 - (\frac{\sum s_i^2}{s_t^2})$:	0.725328947
Cronbach's alpha	0.828947368

Source: self made

When applying equation 1 to the developed instrument, a value of 0.82 was obtained, which means that the questions are homogeneous and the questionnaire is reliable as it does not present a trend that favors the evaluation results. Table 2 shows the values that allowed us to reach this conclusion.

Results

Of the eight children who participated in the validation of the system, all showed a predominance of visual learning style, followed by kinesthetic, so they worked with the instructions that the system had for these two learning styles. They also decided to work with the auditory aspect. In this way, they tested the work for all three learning styles.

On the fourth day of work they were asked to solve the questionnaire shown in the previous section. The description of the results obtained was carried out using the arithmetic mean and the standard deviation. The scale goes from 1 to 4, where 1 means strongly disagree and 4 means strongly agree. Table 3 condenses the results for each statement from survey 1.

Table 3. Results obtained for the survey questions

Statement	Very in disagreement	In disagreement	OK	Strongly agree	Arithmetic average	Standard deviation
1	12.5%	0%	12.5%	75%	3.5	1
2	0%	0%	25%	75%	3.75	0.4
3	0%	0%	25%	75%	3.75	0.46
4	12.5%	0%	62.5%	25%	3.37	0.5
5	25%	0%	25%	fifty %	3	1.3
6	0%	0%	25%	75%	3.75	0.4
7	12.5%	0%	37.5%	fifty %	3.25	1
8	0%	12.5%	25%	62.5%	3.5	0.7
9	0%	12.5%	12.5%	75%	3.6	0.7

Source: self made

In relation to the variable *satisfaction when using the website* (statement 1), the children were very satisfied with the interaction, as they rated this aspect with 3.5/4. The variable *ease of use of the website* was evaluated through three aspects, namely: ease of learning to navigate the site (statement 2), ease of performing the requested actions (statement 5) and ease of remembering its use (statement 8). , which obtained scores of 3.75/4, 3/4 and 3.5/4, respectively. They also stated with a rating of 3.75/4 that they understood all the instructions that the system asked them to perform (statement 6). This result can also be explained due to the passing estimate that the children made about whether the information on the site was clear and understandable (statement 7), which obtained a score of 3.25/4, if they easily found the icons to solve the activities. requested (statement 3), an item that obtained a weighting of 3.75/4, and whether the system showed them error messages when they made a mistake (statement 4), which was judged with 3.37/4.

Finally, the previous values allow us to explain the pleasure that the children had when using the system (statement 9), since they valued this aspect with 3.6/4. In conclusion, it can be said that the children easily learned to work with the website, easily found the information and easily remembered how to use it.

Discussion

The contribution of the built system compared to those presented in the theoretical framework (Bantupalli and Xie , 2018; Dilo con Señas, 2016; Jiménez *et al* ., 2017; Pérez *et al* ., 2017; Sign'n - Inicio, 2019 ; Signamy - Apps on Google Play, 2019) is that it takes two aspects into account : teaching signs so that the child can communicate and evaluating how they are doing them. Furthermore, in both processes the three communication channels (visual, auditory and kinesthetic) are integrated in order to obtain more personalized learning, unlike those presented by Bantupalli and Xie (2018) , Pérez et al . . (2017), Jiménez *et al* . (2017), which only take into account the visual part, leaving aside the auditory and kinesthetic aspects.

In the case of Dilo en señas (Dilo con Señas, 2016), it only has a function to play by watching the video of the sign and relating it to the correct image, but it does not carry out an evaluation of how the child is executing the sign.

In the case of the proposed system, it is not only appreciated whether the child knows the sign or not (since they are not only shown how to do it through images or videos), but it is actually evaluated. Therefore, both the strengths and limitations of the system are shown below.

Strengths

The strengths of this work can be divided into the following categories:

1. System construction:
    a. Customizable interface. In the design of the interfaces, colors and different combination schemes were used to attract children's attention and improve the user experience.
    b. Web system for those users who have access to a computer, and mobile application to work anytime, anywhere.
2. Instruction:
    a. Learning style. It is taken into account for instruction, which strengthens understanding, learning, and achievement of academic objectives.
    b. Knowledge of the signs of letters and numbers to form any word and/or figure through manual spelling, which can also be used to represent ideas that do not have an established sign, such as proper names or technicalities

3. Exercise and evaluation: Performed through image analysis, which provides accurate information about how well each sign is being performed. This is a distinctive feature of the developed system: it examines the execution of the sign that the user himself is performing.
4. General utility: In addition to serving to teach children an alternative form of communication that can reduce the risk of contagion by covid-19 in that population, the system can favor the inclusion of people with hearing disabilities. For example, recently the Secretariat of Public Security of Mexico City trained its staff in the LSM so that they can better relate to citizens who suffer from this disability (Nava, July 31, 2021).

Limitations of the study

The main limitation of this work was during its practical application, since, due to the suspension of face-to-face educational activities, first it was not possible to access a large group of students and, second, probably the effect of social isolation caused the attention of boys and girls between eight and nine years old descended, because after approximately ten minutes they had difficulty remembering the names of the fingers; Furthermore, the participation of men was lower than that of women.

Although there are several factors that could have influenced these reactions, it is true that the lack of face-to-face interaction between students and teachers prevented the continuous reinforcement of learning; Furthermore, continuous exposure to television and/or computers as means to continue learning diminished interest in working with these devices.

Conclusions

The appearance in the world of the SARS-CoV-2 virus, which causes the covid-19 disease, forced the rethinking of many daily activities of the population, since some were limited, while others were completely suspended or carried out with certain restrictions. modifications. However, what remained constant in human beings, due to their very social nature, was their need to express themselves and communicate with their peers, which is why videoconferencing tools have been essential to meet, virtually, with family and friends. However, the return to a new normality after a time of confinement once again represented a risk of contagion due to the reestablishment of social and work relations in person.

The educational field, especially the preschool and primary levels, was a sector susceptible to infections due to the dynamics of interaction between its members. The vulnerability of this sector could have been mitigated by using a form of non-verbal communication , such as sign language. In this sense, this work presented a *software* system developed to instruct, considering their learning style, primary school children about the letters of the alphabet and the numbers of the LMS, with which it is possible to form any word/figure and , in this way, communicate without having to produce sounds.

In this system, a section was also developed to evaluate, through image recognition, the execution of the signs made by the children. This allowed them to have information to improve the implementation of what they learned. Although the operation of this system was limited by the social distancing conditions imposed by the pandemic, the assessment made by a group of children showed that it is feasible to use this system to support the instruction and evaluation of the signs of the alphabet and numbers of the alphabet. LSM. Therefore, it can be indicated that the proposal presented is not only constituted as an alternative, from the trenches of computer systems engineering, to mitigate covid-19 infections in primary school children, but that its use can be expanded to other areas to contribute to reducing the inclusion gap of people with hearing disabilities in society.

Contributions to future lines of research

It is planned to incorporate dynamic sign instruction considering all three learning styles and extend the assessment module to examine more body movements and facial gestures. To do this, the system will be adjusted in terms of interface and determination of learning style so that it can be used as a support tool in the delivery of courses on this language or so that the general population can learn on their own.

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