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Artículos Científicos

Aprovechamiento escolar en aritmética: Objeto de aprendizaje en lengua de señas mexicana para sordos

Scholastic Achievement in Arithmetic: Learning Object in Mexican Sign Language for Deafness People

Realização escolar em aritmética: objeto de aprendizagem da língua gestual mexicana para surdos

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Resumen

El objetivo de este trabajo fue obtener evidencia de que se logra y favorece el aprovechamiento escolar, en específico en el área de la aritmética, con el empleo de un objeto de aprendizaje digital en estudiantes sordos que se comunican mediante la lengua de señas mexicana. Esto a través de una investigación de tipo cuantitativo experimental que consideró una muestra de 30 estudiantes de tercer grado de primaria en el municipio de Querétaro, México, quienes se distribuyeron en dos grupos: de control y experimental.

El instrumento y los datos obtenidos se validaron mediante la prueba estadística parametrizada *t-Student*: el resultado fue de 95 % de intervalo de confianza. Además, se midió la confiabilidad de la prueba previa y la prueba posterior con el coeficiente de correlación de Pearson, y el aprovechamiento escolar se comprobó con el indicador estadístico de la ganancia normalizada de Hake. De esta manera, se concluyó que se favorece el aprovechamiento escolar con el uso de tecnología educativa. Se determinó que en el grupo experimental se observó una mejoría moderada en las operaciones de adición, sustracción, multiplicación y división de la aritmética, en comparación con las reportadas en el grupo de control. Finalmente, se recomienda la participación activa de las personas con déficit auditivo en la educación.

Palabras clave: aprendizaje en línea, aritmética, educación de sordos, experimento educacional, investigación pedagógica, programa informático didáctico.

Abstract

The objective of this work was to obtain evidence that school achievement is favored, specifically in the area of arithmetic, with the use of a digital learning object in deaf students who communicate through the Mexican sign language. This through an experimental quantitative research that considered a sample of 30 third grade students in the municipality of Querétaro, Mexico, who were divided into two groups: control and experimental.

The instrument and the data obtained were validated using the t-test: the result was 95% confidence interval. In addition, the reliability of the previous test and the subsequent test was measured with the Pearson correlation coefficient, and school achievement was checked with the statistical indicator of Hake's normalized gain. In this way, it was concluded that school achievement is favored with the use of educational technology. It was also determined that in the experimental group a moderate improvement was observed in the arithmetic operations of addition, subtraction, multiplication, and division, compared to those reported in the control group. Finally, the active participation of people with hearing impairment in education is recommended.

Keywords: e-learning, arithmetic, education of the deaf, experimental education, pedagogical research, educational software.

Resumo

O objetivo deste trabalho foi obter evidências de que o desempenho escolar é alcançado e favorecido, especificamente na área da aritmética, com o uso de um objeto de aprendizado digital em estudantes surdos que se comunicam através da linguagem gestual mexicana. Isso por meio de uma pesquisa quantitativa experimental, que considerou uma amostra de 30 alunos da terceira série do município de Querétaro, México, divididos em dois grupos: controle e experimental.

O instrumento e os dados obtidos foram validados por meio do teste estatístico parametrizado t-Student: o resultado foi um intervalo de confiança de 95%. Além disso, a confiabilidade do teste anterior e do teste subsequente com o coeficiente de correlação de Pearson foi mensurada, e o desempenho escolar foi verificado com o indicador estatístico do ganho normalizado de Hake. Dessa forma, concluiu-se que o desempenho escolar é favorecido com o uso da tecnologia educacional. Foi determinado que no grupo experimental foi observada melhora moderada nas operações de adição, subtração, multiplicação e divisão da aritmética, em comparação com as relatadas no grupo controle. Por fim, recomenda-se a participação ativa de pessoas com deficiência auditiva na educação.

Palavras-chave: aprendizagem on-line, aritmética, educação de surdos, experimento educacional, pesquisa pedagógica, programa didático de computador.

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Introduction

This research proposes that the expected school performance in the area of arithmetic in deaf people be achieved through a digital pedagogy intervention that favors the construction of mathematical concepts and the set of procedural operations. “In every teaching process, even if you have expected learning for all students alike, you must take into account that the way to reach them can be different for different students” (Secretariat of Public Education [SEP], 2018, p. 13).

That is why the spaces, strategies, materials and technologies applied to education have to be considered to address the diversity of specific educational needs of students: by taking advantage of new learning environments, which are present today in teaching processes, thanks to the use of information and communication technologies (ICT). New media such as mobile phones, tablets and computer equipment facilitate the use and application in learning spaces based on the so-called personal learning environment (PLE), in collaborative web spaces, social networks, those based on games and the so-called massive open online courses (MOOC) (Díaz, Baena and Baena, 2018, pp. 1-19). Of course, the importance of teachers, specialists, support staff and family members of people with hearing impairment is equally important, since they are the ones who implement these improvements and are the facilitators of carrying out these educational practices.

To achieve this:

> The theme or subject must be defined, establish who will be the collaborating teachers, the type of content that will be used, how the modules and lessons will be integrated, what the communication spaces will be and the way in which student participation will be encouraged, the platform that will be used and the dissemination mechanisms of the course (Escudero y Nuñez, 2019, p. 135).

The World Health Organization [WHO] (2011) reports in its summary of the World Report on Disability the following: “The evidence presented in this Report indicates that many of the obstacles faced by persons with disabilities are avoidable, and that the disadvantages associated with disability can be overcome ”(p.18).

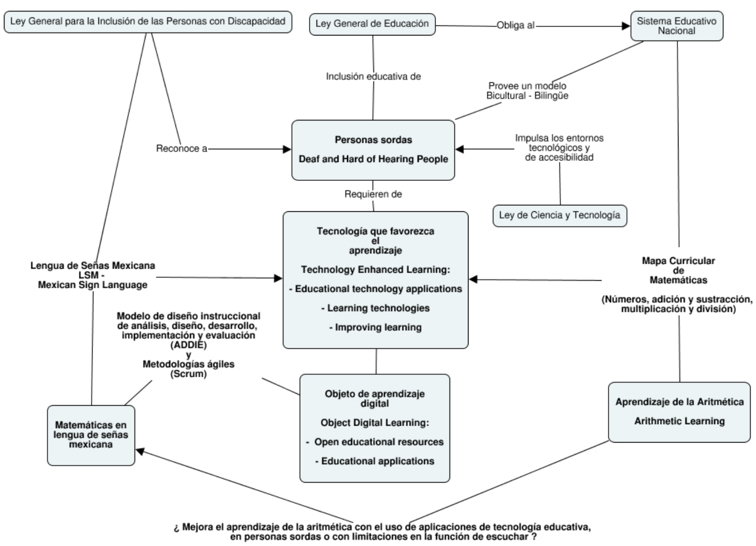
In this regard, deaf people make up one of the vulnerable groups in society, and like the rest they need education to improve their quality of life. As regards the environment of the Mexican education system and current regulations, referring to the General Law of Education, the Law of Science and Technology and especially the General Law for the Inclusion of Persons with

Disabilities, which, in their Last reform published in 2018, in its chapter III dedicated to education, article 12 section VI, says the following:

> Provide students with disabilities; materials and technical aids that support their academic performance, trying to equip the schools and educational centers with Braille books, teaching materials, support of Mexican sign language interpreters or Braille system specialists, computerized equipment with technology for blind people and all those supports that are identified as necessary to provide quality education (Cámara de Diputados, 2018, p. 10).

At the dawn of this work it was identified that one of the research lines of educational technology is responsible for studying that the use of technology improves learning through digital learning objects, as shown in Figure 1.

Figura 1. Contexto de la investigación cuantitativa experimental



Fuente: Elaboración propia.

Thus, the use of the deaf student in the subject of mathematics, and in particular in arithmetic, an area that studies numbers and operations made with them, serves as a background to begin with this research.

As part of the preliminaries, the curriculum map and the dosage of knowledge in mathematics for the first three years of primary school were analyzed in the books of the SEP teacher (2018). And the Mexican Sign Language Dictionary was consulted, particularly the numbers section and some related words that were used in the construction of the sign language videos with subtitles (Serafin, 2015, pp. 224-237).

Regarding the literature and some recent works that serve here as a frame of reference, it was found that, in 2018, the MatLibras educational game was used to teach numbers in Brazilian sign language. According to Pontes, Pinheiro and Furlan (2018), MatLibras has a promising future in educational environments, as it encourages the learner's motivation through a pre-competition training promoted by the software itself, which also has a modular architecture that allows you to configure the game for other sign languages. On the other hand, in 2015 a study was carried out on the design and evaluation of a multimedia prototype for the teaching of arithmetic in a student population of deaf people in Thailand, specifically in children aged seven and in counting operations, sums and subtraction The authors identified high rates of motivation and easy understanding in autonomous learning (Techaraungrong, Sukasakulchai, Kaewprapan and Murphy, 2015).

A year ago, in 2014, a study was undertaken to describe the development and evaluation of a distance course for deaf people dedicated to computer learning and based on an advanced method of pedagogical index that was adopted in Slovenia. This course included video transmissions with subtitles and sign language videos with interpreters (Debevc, Stjepanovič and Holzinger, 2014). Along the same lines, an initiative was found that was sponsored in 2013 by the Lifelong Learning Program of the Leonardo da Vinci project, where deaf people from the countries of Greece, Cyprus, Italy and England had to study with Web 2.0 tools: blogs, wikis, social networks and the typical hypermedia, coupled with lip reading, sign language videos and other learning activities to acquire knowledge of electronic commerce, international accounting standards and face dyscalculia (Drigas, Vrettaros, Argiri y Bardis, 2013).

Finally, in 2010 a study was published on the improvement of learning in students with deafness based on sign language and text; There, some barriers to learning the text of a reading and sign language for the deaf were evident. According to the authors, if better performance is desired in both formal and informal educational settings, higher expectations are necessary. (Borgna, Convertino, Marschark, Morrison y Rizzolo, 2010).

Research Method

Investigation Procedure

From the book Methodology of research by Hernández, Fernández and Baptista (2010), where the fundamental stages of the general research process are raised, which refer to the problem statement, literature review, data collection, analysis of the data and the report of results, features were found in this investigation that favor the quantitative approach. Because data collection will be used to test a hypothesis based on numerical measurement and statistical analysis. Under these premises, the following is defined as the main objective: Obtain evidence that the academic achievement of arithmetic is achieved or favored in a population of deaf students in the third grade of primary school in the municipality of Querétaro, Mexico, with the use of a learning object in Mexican sign language.

The experimental quantitative method allowed to fulfill the objective of the study, answer the research question and test the research hypothesis.

In this regard, the research question was enunciated in the following terms: Will it be possible to obtain an improvement in school achievement with the use of the learning object designed in Mexican sign language for deaf people in arithmetic in the experimental group compared to the control group?

The variable or independent research construct was defined, which refers to the object of learning in Mexican sign language for the deaf, in correlation with the variable or dependent research construct, which will allow us to measure school achievement.

Thus, the design of this experiment consists of two research groups: the control group with 15 participants and the experimental group with 15 participants, both with previous knowledge of arithmetic. The research hypothesis, consequently, is presented as a statement that answers the research question. And it is shown in table 1.

Tabla 1. Hipótesis de investigación.

Hipótesis de investigación **Sección: Aritmética**	**Hipótesis nula** **Sección: Aritmética**
Hi_{oaycn}: Se logró obtener evidencia de una mejoría en el aprovechamiento escolar en el grupo experimental en comparación con el grupo de control, con el uso y aplicación del instrumento de medición.	Ho_{oaycn}: No se logró obtener evidencia de una mejoría en el aprovechamiento escolar en el grupo experimental en comparación con el grupo de control, con el uso y aplicación del instrumento de medición.

Fuente: Elaboración propia

The investigation procedure was based on comparing two research groups. As we have seen, the first one was called the control group, where the independent variable related to the object of learning in the Mexican sign language for the deaf is absent, and the traditional method used for learning arithmetic in the educational model is maintained. Bicultural-bilingual for deaf people. While the experimental group receives the experimental stimulus with the presence of the independent variable. In both groups, however, the dependent variable is present, which is defined as school achievement, which is the one that will be measured through the comparison of these two groups that are similar to each other and equivalent, and through the technique of pairing, namely, that they have prior knowledge of arithmetic.

In order to carry out the investigation, the object of learning in Mexican Sign Language for the Deaf known as Mate with Signs was designed and developed, from which the Public Registry of Copyright Certificate No. 03-2016-081911254700-01 was obtained in the National Copyright Institute, belonging to the Ministry of Culture of the Federal Government. It was decided to develop this digital learning object for mobile devices through the agile hybrid software engineering methodology. Thus, four work groups were organized that had the role of development, change control, client and testing. The life cycle was followed iteratively and always presenting the prototype to the end user for feedback (Leiva and Villalobos, 2015). The Android Studio and Adobe Acrobat suites were used per se for their design and development, with the purpose of operating on tablets and smartphones with Android operating system. Figure 2 shows the object of learning in Mexican sign language for the deaf.

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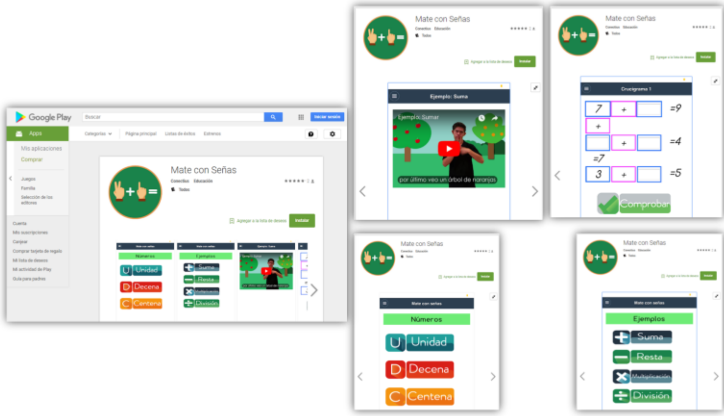
Figura 2. Objeto de aprendizaje digital (Mate con señas)



Fuente: Elaboración propia

Based on what is mentioned in that in a society with notable changes and with technological developments available, significant adjustments in education systems are demanded, in general terms, the systematic and coordinated use of different technologies such as mobile devices, tablets or phones Smart, and applications such as GeoGebra, WolframAlpha, Khan Academy, can contribute to the construction of student knowledge (Santos, 2015). And it is then that the digital pedagogical proposal of the intervention strategies suggested for mathematics for people with hearing disabilities by Cardona, Arámbula and Vallarta (2014, pp. 41-48) was considered. So the sections of the object of learning in Mexican sign language for the deaf and the proposed activities that are recommended for numbers, their relationships and operations are shown through videos in Mexican sign language with Spanish subtitles with interpreters who use the language and ideograms.

In figure 3, the typology and ideograms are used to explain that arithmetic is a branch of mathematics that studies numbers and the operations that are performed with them.

Figura 3. Rama de las matemáticas (aritmética)

Fuente: Elaboración propia.

In Figure 4, on the other hand, it is intended that the deaf person establish the relationship between images and numbers, aided initially by the teacher or his classmates and then through self-learning. The concepts of numbers and units are described here. And symbols, images, subtitles in Spanish and the association between the numbers of the decimal system and the use of figures to achieve this are shown; all of the above with the support of the sign interpreter.

Figura 4. Concepto de números y unidades. Ejemplos con imágenes-números

Fuente: Elaboración propia

Figure 5 explains the concept of tens and presents several examples where images are associated with numbers.

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Figura 5. Concepto de decenas. Ejemplos con imágenes-números

Fuente: Elaboración propia

In figure 6, meanwhile, the concept of hundreds and the relationship between images and numbers are explained.

Figura 6. Concepto de centenas. Ejemplos con imágenes-números

Fuente: Elaboración propia

In figure 7, and given the recommendation to encourage deaf girls and boys who approach knowledge with the graphic representation of the numbers a series of exercises and examples that will increase in difficulty, begins with the first operation, reference to the addition; there, everyday situations, games and routine activities are used to perform these operations, through the composition of corresponding quantities and numbers.

Figura 7. Concepto y ejemplos de la adición (sumar). Ejemplos con imágenes-números y números-números

Fuente: Elaboración propia

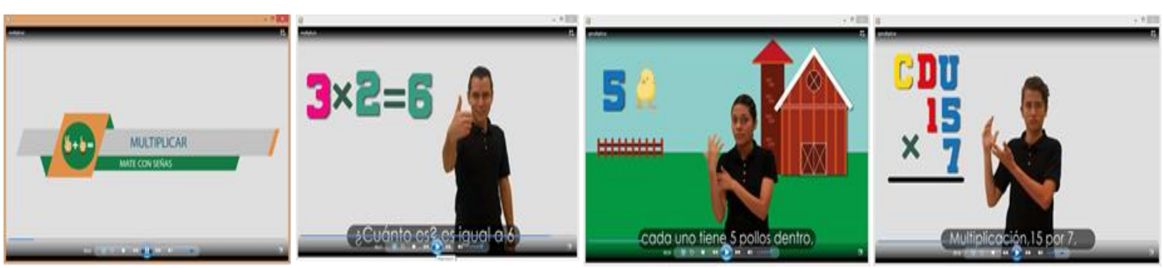
Figure 8 describes the concept of subtraction and several examples.

Figura 8. Concepto y ejemplos de la sustracción (restar). Ejemplos con imágenes-números y números-números

Fuente: Elaboración propia

In addition, Figure 9 describes the concept of multiplication and a series of examples with greater complexity.

Figura 9. Concepto y ejemplos de la multiplicación (multiplicar). Ejemplos con imágenes-números y números-números



Fuente: Elaboración propia.

Finally, figure 10 shows the concept of division and several examples that foster the understanding and construction of mathematical knowledge through the relationships between images and numbers, as well as numbers with numbers.

Figura 10. Concepto y ejemplos de la división (dividir). Ejemplos con imágenes-números y números-números

Fuente: Elaboración propia

Also, the instrument was designed that served as a standardized test and was used to measure school achievement in arithmetic. It was designed considering the curriculum map and the dosage of the expected learning for the first three grades of elementary school in the subject of mathematics. It was presented as a workbook with the four operations to be evaluated and a cross-section of numeric crosswords of arithmetic operations was incorporated. This was applied at two different times in each research group.

It should be noted that the dependent variable was determined quantitatively in both research groups. This indicator is used to measure school achievement in science subjects; That is why it was used.

There is a recent study published by Sanhueza, Bravo, Fáundez and Utreras (2018), where we sought to know the impact that ICTs have on middle school physics students, under the Ministry of Education of Chile, which reported a conceptual gain of Medium to moderate hake. In that same country, but in 2016, a proposal was carried out that aimed to develop improvement projects for the teaching of science at the University of Concepción and where the effectiveness of the acquisition of significant learning was verified through the Hake factor (Bravo, Ramírez, Fáundez and Astudillo, 2016). In that same trend, in the study by Barragán (2016) the reported use was measured by means of the standardized gain or Hake factor, result of the application of the operational criteria of the corresponding principles that were used for the development and application of a didactic strategy, and that generated a continuous improvement in the learning.

Following these examples, in this work the same measuring instrument was applied simultaneously in both groups: previous test and subsequent test. In addition, the results obtained were validated through the parameterized statistical test method known as t-Student; Finally, the reliability or reliability of the instrument was assessed using Pearson's correlation coefficient, considering that the population sample was 30 participants (n = 30), with 14 degrees of freedom in each group and 95% confidence interval as stability measure to assess the significance of the results obtained and validate the experiment. And in this way give certainty to the values obtained from the statistical indicator known as learning gain or Hake factor for each of the sections of the instrument.

The following is the way in which it was performed in data analysis in the subtraction or subtraction operations section for the control and experimental group.

Tabla 2. *Prueba T-Student y Ganancia Normalizada Hake. Grupo de control. Sustracción*

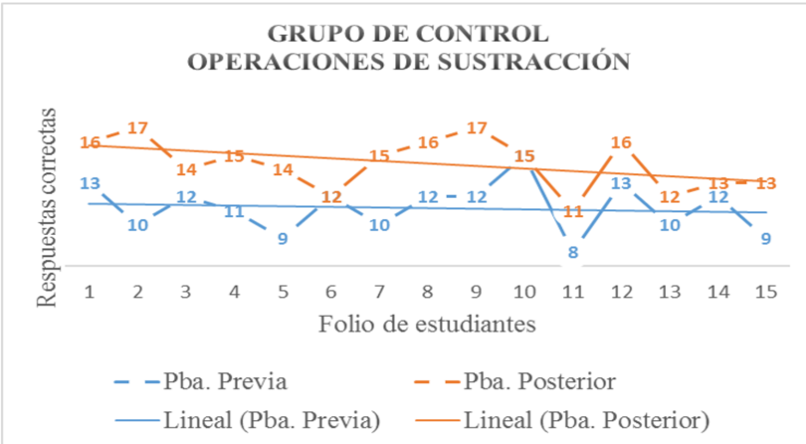
	Prueba previa	**Prueba posterior**	**Factor Hake**
Media	11.2000	14.4000	0.03603604
Varianza	3.457142857	3.542857143	
Observaciones	15	15	
Coeficiente de correlación de Pearson	0.444931316		
Diferencia hipotética de las medias	0		
Grados de libertad	14		
Estadístico *t*	-6.2872		
P(*T* <= *t*) una cola	0.00000999		
Valor crítico de *t* (una cola)	1.761310136		
P(*T* <= *t*) dos colas	0.000020		
Valor crítico de *t* (dos colas)	2.144786688		

Fuente: Elaboración propia

Taking into account Table 2, which shows the results of the t-Student parameterized test and the Hake standardized gain for the control group, it was observed that, in said group, data collection offers a very consistent degree of reliability and consistent with the results when obtaining a weak positive correlation of 0.4449.

Graphically, it was observed that the normalized Hake gain is low, as this is reflected in the linear trend lines that were obtained in the two moments of the experiment, stable to slightly descending in the previous test and descending in the subsequent test.

Figura 11. Gráfica con líneas de tendencia lineal. Grupo de control. Sustracción



Fuente: Elaboración propia

The mean and variance show the comparison of the two tests performed and at the two different moments of the experiment obtained in the t-Student test.

Although favorable the results, the achievement or improvement in learning is significantly low. In order to verify the research hypothesis, the level of significance, which is high, and the sample distribution, were considered when applying the parameterized test as a stabilizing measure of the experiment.

On the other hand, table 3 shows the results of the t-Student parameterized test and the Hake normalized gain for the experimental group.

It was observed that, for this second group, data collection offers a degree of reliability that is very consistent and consistent with the results obtained by presenting a weak positive correlation of 0.3395, and maintaining a close relationship with the validity of the measuring instrument of 99.99958 %. The normalized gain is moderate.

Tabla 3. Prueba *t-Student* y de ganancia normalizada Hake. Grupo experimental. Sustracción

	Prueba previa	**Prueba posterior**	**Factor Hake**
Media	10.53333333	14.73333333	0.04694486
Varianza	5.266666667	1.923809524	
Observaciones	15	15	
Coeficiente de correlación de Pearson	0.339592125		
Diferencia hipotética de las medias	0		
Grados de libertad	14		
Estadístico *t*	-7.2539		
P(*T* <= *t*) una cola	0.00000210		
Valor crítico de *t* (una cola)	1.761310136		
P(*T* <= *t*) dos colas	0.00000420		
Valor crítico de *t* (dos colas)	2.144786688		

Fuente: Elaboración propia

In this case, graphically the linear trend lines look stable and almost parallel both in the previous test and in the subsequent test. The mean and variance obtained are slightly better than those reported in the control group and show the comparison of the two tests performed at the two moments of the experiment. The research hypothesis is also checked, considering the level of significance obtained in this group, which is high and higher than the control group, and the sample distribution of the values obtained from this population: there is a moderate to high improvement in Arithmetic learning in the experimental group compared to the control group.

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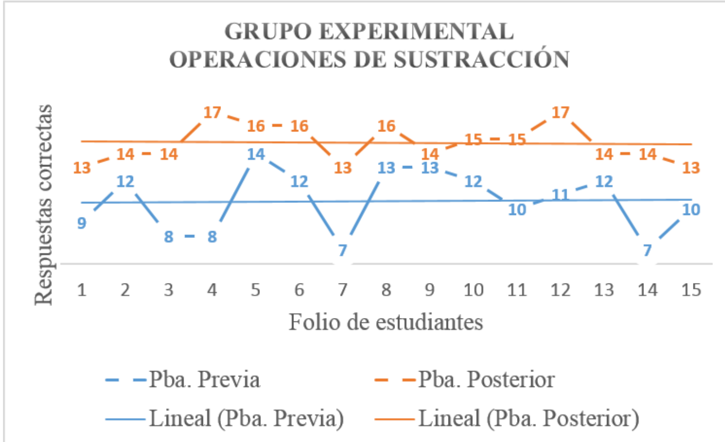
Figura 12. Gráfica con líneas de tendencia lineal. Grupo experimental. Sustracción



Fuente: Elaboración propia

Results

After having performed the quantitative analysis of the data obtained in the research during the period from September to November 2018, the findings found through the correlational inference of statistical data and the results obtained experimentally in our population are presented below. of deaf people who are in the third year of primary school at the Helen Keller Multiple Care Center, located in the state capital of Querétaro, Mexico, specializing in the care of girls and boys with deafness at preschool, primary and high school.

The results show that our main objective of the research was achieved: by obtaining evidence that in the experimental group, where the object of learning in Mexican sign language for the deaf was present, an improvement in the use was achieved school in learning the four arithmetic operations compared to the control group.

Table 4 shows the results of statistical inference for the two research groups and the learning variables evaluated in the arithmetic operations section.

In both research groups, the results obtained in the statistical indicator of the mean (¯X) were better in the subsequent test than in the previous test. It is noteworthy that in the experimental group the direction of the Pearson correlation coefficient (r_xy) was positive, that is, it approached 0.50, which is an average positive correlation, and the numerical value reflects the magnitude of the correlation that, compared With the significance P ($T \leq t$), it exceeds by far the level of significance raised from 0.05 in the experimental group compared to the control group. When a confidence is found that the correlation is true as it is greater than 95% and a 5% probability of error. In the control group a negative sign was presented, which changed the direction of the correlation direction to a negative average when approaching -0.50, which affected the multiplication learning variable, and the division presented an advantage more border school. Therefore, it is inferred that a low improvement in the learning of arithmetic was found in the control group, as there was no presence of the learning object in Mexican sign language for the deaf. It should also be considered that in the experimental group the order in which there was a moderate improvement was in multiplication, addition, subtraction and finally in division; as opposed to the order presented by the control group, where a low improvement was found starting with the subtraction, multiplication, addition and division.

Tabla 4. Resultados por grupo de investigación y variable de aprendizaje evaluada

Medición de la mejora del aprendizaje de la aritmética. Operaciones aritméticas								
Grupo de investigación de control								
Variable	Prueba previa		Prueba Posterior		Prueba t para medias de dos muestras emparejadas			Ganancia normalizada
Operaciones aritméticas	$\overline{X}$	σ^2	$\overline{X}$	σ^2	r_{xy}	t	$P(T \leq t)$ **dos colas**	***Factor g***
Adición	14.00	4.57	16.20	5.02	0.8491	-7.05	0.0000057	0.0255814
Sustracción	11.20	3.45	14.40	3.54	0.4449	-6.28	0.0000200	0.0360360
Multiplicación	10.53	6.55	12.86	2.83	-0.4295	-2.49	0.0256012	0.0260805
División	10.66	1.52	11.33	5.38	0.3409	-1.16	1.2653555	0.0074627
Grupo de investigación experimental								
Variable	Prueba previa		Prueba Posterior		Prueba t para medias de dos muestras emparejadas			Ganancia normalizada
Operaciones aritméticas	$\overline{X}$	σ^2	$\overline{X}$	σ^2	r_{xy}	t	$P(T \leq t)$ **dos colas**	***Factor g***
Adición	13.80	6.02	18.00	2.42	0.4293	-7.15	0.0000049	0.0487239
Sustracción	10.53	5.26	14.73	1.92	0.3395	-7.25	0.0000042	0.0469449
Multiplicación	10.93	2.78	15.40	5.54	0.1528	-6.48	0.0000144	0.0501497
División	11.33	2.38	14.13	3.98	0.0541	-4.41	0.0005857	0.0315789
Nota: $\overline{X}$ = Media; σ^2 = Varianza; r_{xy} = Coeficiente de correlación de Pearson; t = Estadístico t; $P(T \leq t)$ = Prueba de hipótesis; $Factor\ g$ = Ganancia normalizada o factor Hake.								

Fuente: Elaboración propia

With this information it was shown that the research hypothesis is confirmed in the sense that moderate and superior school achievement was observed in the learning of arithmetic in the operations of addition, subtraction and multiplication in the experimental group compared to the group of control; not so, however, in the division operation, where it was not fulfilled in the sense that a low performance was observed, but finally a school achievement. In addition, it is possible to answer the research question for this section of arithmetic operations, by affirming that the expected learning or the improvement of these in the school use of arithmetic in deaf people with the use of educational technology is achieved. And as a result, it was possible to acquire mathematical skills by being favored with the use of technology. In addition to this first section, the numeric crossword section of arithmetic operations was incorporated into the study as a playful-pedagogical element.

Therefore, the results shown in Table 5 are accepted with great expectation. The results of statistical inference for the two research groups and the learning variables evaluated for this section.

It was observed that in both research groups the results obtained in the statistical indicator of the mean (¯X) were better in the subsequent test than in the previous test. In this case it is also underscored that in the experimental group the direction of the Pearson correlation coefficient (r_xy) was positive, that is, it approached in the operation of the addition to 0.50, in the subtraction and division exceeded 0.50, considered as an average positive correlation, and finally the multiplication almost becomes a considerable positive correlation. The numerical value reflects the magnitude of the correlation compared to the significance P (T ≤ t). It far exceeds the level of significance of 0.05 raised in the experimental group compared to the control group.

Tabla 5. Tabla de resultados por grupo de investigación y variable de aprendizaje evaluada

Medición de la mejora del aprendizaje de la aritmética. Crucigramas numéricos.								
Grupo de investigación de control								
Variable	Prueba previa		Prueba posterior		Prueba *t* para medias de dos muestras emparejadas			Ganancia normalizada
Crucigramas numéricos	$\bar{X}$	σ^2	$\bar{X}$	σ^2	r_{xy}	t	$P(T \leq t)$ **dos colas**	$Factor\ g$
Adición	35.73	12.7	41.26	68.3	0.0799	-2.451	0.0279548	0.0860996
Sustracción	39.33	12.0	42.06	51.0	0.6255	-1.869	0.0826224	0.0450549
Multiplicación	36.40	6.54	38.93	24.4	0.5326	-2.341	0.0344910	0.0398323
División	27.40	10.6	32.26	9.49	0.5701	-6.391	0.0000167	0.0670340
Grupo de investigación experimental								
Variable	Prueba previa		Prueba posterior		Prueba t para medias de dos muestras emparejadas			Ganancia normalizada
Crucigramas numéricos	$\bar{X}$	σ^2	$\bar{X}$	σ^2	r_{xy}	t	$P(T \leq t)$ **dos colas**	$Factor\ g$
Adición	37.66	22.3	43.80	27.3	0.4882	-4.699	0.0003416	0.0983957
Sustracción	41.20	17.1	45.60	25.4	0.5650	-3.912	0.0015630	0.0748299
Multiplicación	37.20	17.1	41.53	29.5	0.7242	-4.470	0.0005284	0.0690021
División	31.60	22.5	36.66	29.9	0.5387	-3.964	0.0014100	0.0740741
Nota: $\bar{X}$ = Media; σ^2 = Varianza; r_{xy} = Coeficiente de correlación de Pearson; t = Estadístico t; $P(T \leq t)$ = Prueba de hipótesis; $Factor\ g$ = Ganancia normalizada o factor Hake.								

Fuente: Elaboración propia

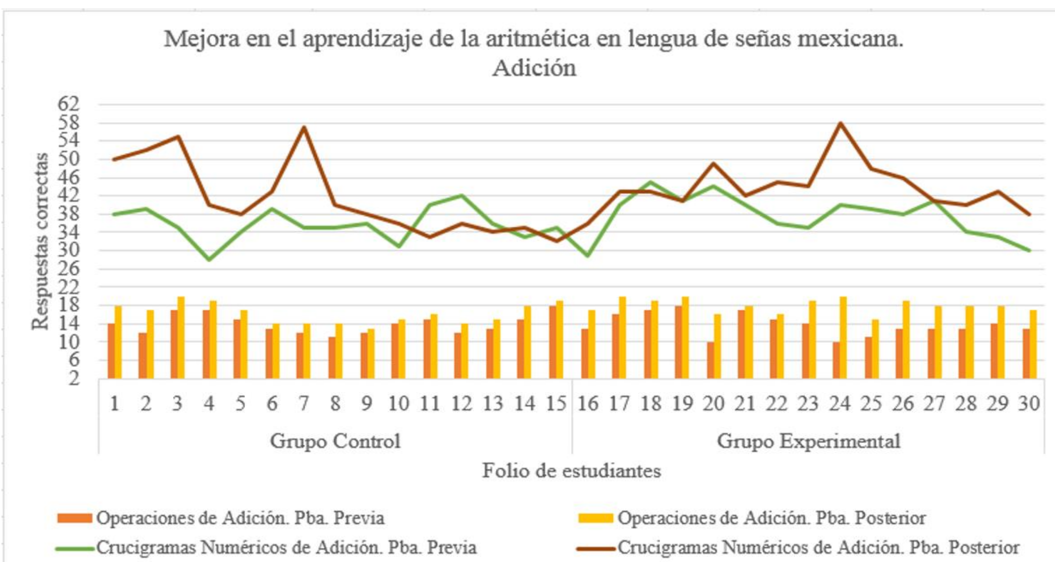
When finding a confidence that the correlation is true to be greater than 95% and 5% probability of error. In the control group, a correlation considered as very weak positive was presented in the addition operation, but in the subtraction, multiplication and division operations the value of the correlation coefficient is medium positive. In the control group there was a moderate to low improvement in school achievement in arithmetic; and it was better in the following order: addition, division, subtraction and ultimately multiplication. In the experimental group, meanwhile, there was a moderate to high improvement in the following order: addition, subtraction, division and multiplication.

With this information we prove that the research hypothesis is fulfilled for the four arithmetic operations through the numerical crosswords; in the sense that moderate to high performance was observed in the experimental group compared to the control group.

We also confirm that the main objective of the investigation is met. It stands out that the play section of the object of learning in Mexican sign language for the deaf was well accepted and caused the best indicators in school achievement in learning arithmetic in the experimental research group. Similarly, the research question for this section is answered, by stating that the expected learning or improvement in arithmetic is achieved in the numeric crossword section of arithmetic operations in deaf people in the experimental group, compared with the findings of the control group.

Figures 13, 14, 15 and 16 show the results obtained in the two research groups in each of the variables of arithmetic operations measured, both obtained in previous tests and in subsequent tests with the same Research instrument

Figura 13. Resultados obtenidos. Adición



Fuente: Elaboración propia

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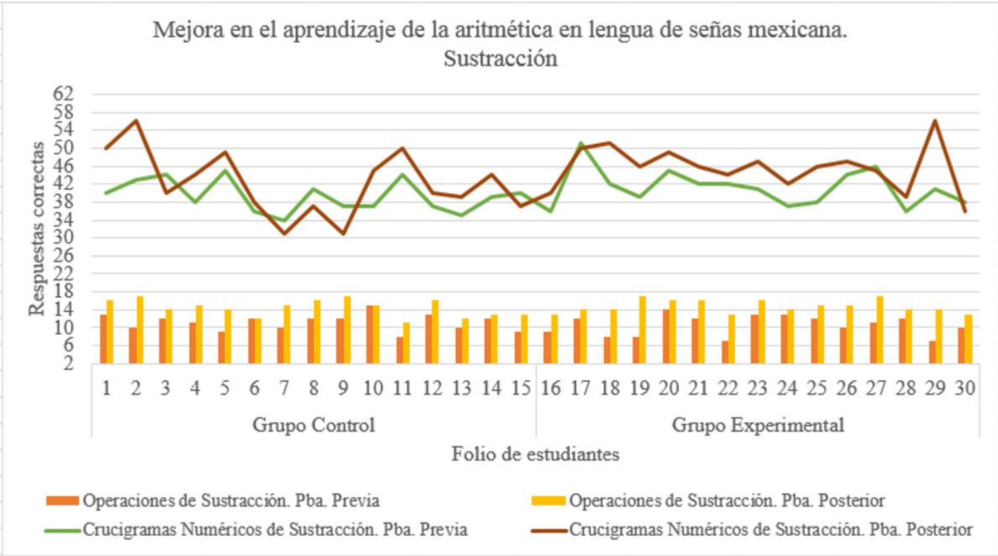
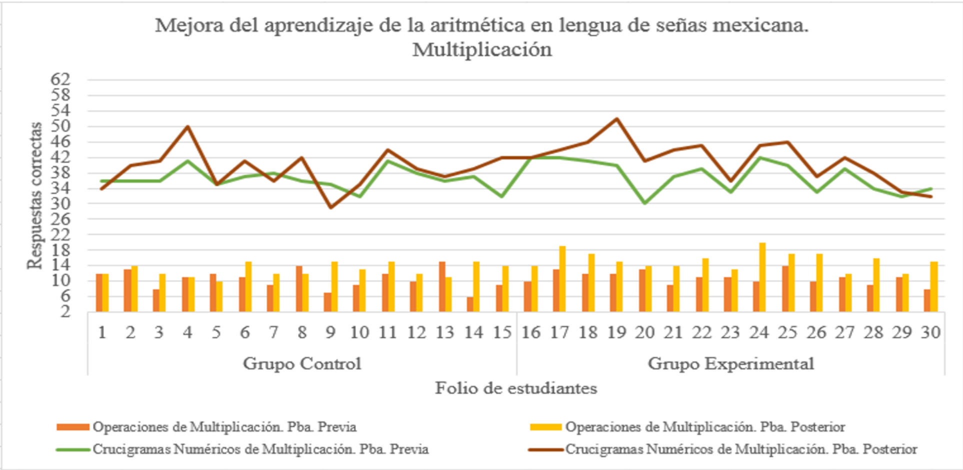
Figura 14. Resultados obtenidos. Sustracción



Fuente: Elaboración propia

Figura 15. Resultados obtenidos. Multiplicación



Fuente: Elaboración propia

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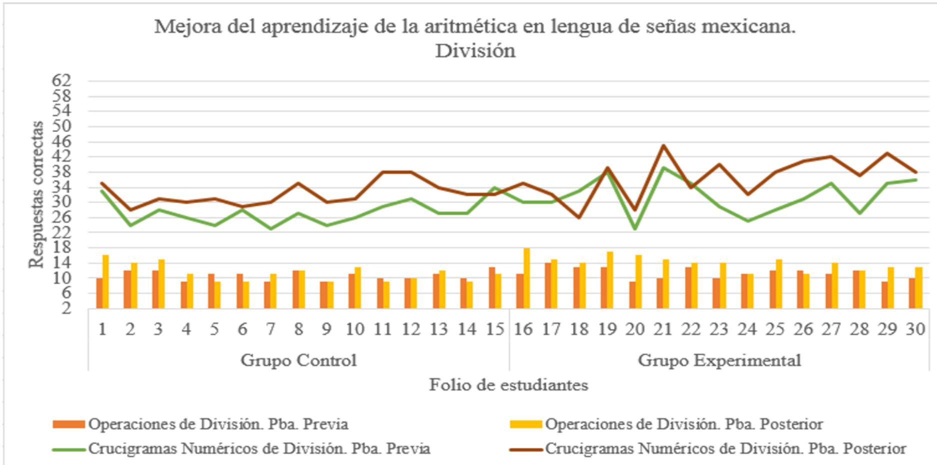
Figura 16. Resultados obtenidos. División



Fuente: Elaboración propia

It remains as a reflection that the handling of numerical crosswords represented for them, for the students, an interesting challenge and motivated them to obtain the best results. That is, they are willing to experience other educational strategies different from the usual ones that allow them a better academic achievement. This component was incorporated both in the data collection instrument and in the object of learning in Mexican sign languages for the deaf used.

Discussion

Given what has been reported in the international context, the theoretical support of the use of ICTs by means of new learning environments, which are favored by the use of new media. With regard to learning spaces based on games, our research uses numerical crosswords and interactive exercises to learn the arithmetic operations performed with numbers compared to the MatLibras educational game, which only teaches numbers via games (Pontes et al., 2018). We also teach arithmetic numbers and operations with videos in Mexican sign language with Spanish subtitles. It also coincides with the work done by Techaraungrong et al. (2015) in Thailand, with a seven-year-old student population of deaf people, who with multimedia taught counting, addition and subtraction. This article considers learning spaces based on personalized and autonomous learning. Our research also contributes to a sector of this population slightly older in age, which allowed to complete the multiplication and division operations, and facilitates the personalization of learning by using the cell phone, tablet and personal computer for the use and application of the Learning object in Mexican sign language for the deaf. Similar to studies done in Slovenia, Greece, Cyprus, Italy and England, where the design of distance courses is used with the use of Web 2.0 components, sign language videos with interpreters aimed at learning environments Formal and informal with emphasis on MOOC, collaborative web spaces and social networks, here the use of technology in education is used to address the diversity of specific educational needs.

The involvement and participation of deaf people in education is outstanding. They themselves participated both in the design and development of the learning object: they became the builders and users of this pedagogical technology in modern educational environments.

Conclusions

This research contributed to the educational community and to those who attend the diversity of the specific needs of the student with hearing impairment in their learning of arithmetic, the evidence that a moderate improvement in school achievement was found with the support of an educational technology designed and implemented in an appropriate learning environment for educational inclusion practices. Technology applied to education encourages self-learning; the coverage is extended to other latitudes and the number of beneficiaries is greater.

Result of the inferential statistical analysis and the level of significance in the sample distribution obtained, it was observed that the experimental group presented an improvement in the four arithmetic operations compared to the control group.

After having carried out this study, a theoretical value was identified with a practical implication according to the new educational environments, the media and the technologies applied to education.

Finally, it was contributed to deaf community members who reside in Querétaro actively participate in this educational research; and made it clear both for them and for us the advisability of promoting learning with the use of technology as a differentiating strategy in favor of their school achievement, academic training and educational inclusion.

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