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Diagnosis of arithmetic-algebraic lag in rural high school students: Impact of the COVID-19 pandemic on fundamental mathematical competencies at CETIS 167, Milpa Alta

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Abstract: The purpose of this study was to identify the academic and socioeconomic conditions that influence the learning of algebra and arithmetic in students at CETIS No. 167, in the municipality of Milpa Alta, considering the effects of the COVID-19 pandemic. The research was guided by a quantitative paradigm, with a non-experimental, correlational approach, whose methodology considered the application of two instruments: a diagnostic evaluation of 16 items and a survey of parents, with 21 items, for a sample of 301 students with scientific intent. Based on the above, it was determined that 65.44% of the students have problems with the hierarchy of operations and algebraic reasoning, which can be due to the fact of having no classes in person and the insufficient use of papers. It was also observed that 40.2% do not have family members professionally trained, affecting the generalization of the students' academic achievement expectations. The conclusion was drawn that the development of practical teaching strategies mediated by technology is needed in order to develop mathematics skills and context-based learning.

Keywords: *COVID-19, Diagnosis, Lag, mathematical skills, Pandemic.*

1. Introduction

In general, mathematics education is one of the pillars of the education system from secondary level onwards, as students are taught skills that are essential for future university and professional life. However, basic arithmetic and algebra concepts have long been a challenge in teaching. The outbreak of COVID-19 has made this even more difficult. Hernández Sampieri et al. [1] argue that the quantitative approach to scientific research allows results to be generalized and behavioral patterns to be established that are regularities in the phenomenon of learning.

The context surrounding the Milpa Alta municipality, characterized by rurality and the socio-economic diversity of its inhabitants, has particular characteristics that influence students' academic performance. In this regard, Rodríguez Medina et al. [2] stated that 79.85% of farmers in this region cultivate an average of between 1,001 and 10,000 m^2, which reflects small-scale production and living conditions that shape the socioeconomic profile of families. This sociocultural reality also influences the aspirations of CETIS 167, based in the town of San Salvador Cuauhtenco.

The COVID-19 pandemic has been a turning point in education and has completely disrupted teaching and learning. In the 2020/21 school year, virtual teaching literally covered half of the year, as the lockdown began in April and lasted until June 2021, characterized by serious disruptions to the educational process. Some subjects, such as mathematics, require continuous practice and close

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monitoring of the teacher's response. However, in this context, failing students was prohibited, and a minimum grade of 6 was allowed. Did this mean that the course was made easier in extraordinary circumstances? Solheim and Milenio [3].

Likewise, in arithmetic and algebra, one of the most demanding foundations is the mastery of the hierarchy of operations, which is the basis for more sophisticated processes. Furthermore, Carpenter et al. [4] mention relational thinking as the ability to pay adequate attention to the set of numerical structural relationships, a key competence to be developed before tackling more advanced algebraic topics. The rapid identification of deficiencies in these early foundations is important if timely interventions are to be implemented.

2. Purpose of the Study

With the aim described above, the purpose of this research is to assess the impact of the COVID-19 pandemic on the learning of fundamental concepts of arithmetic and algebra among students at CETIS 167 in Milpa Alta. A quantitative analysis will be used to identify specific deficiencies in the mastery of the hierarchy of operations and basic arithmetic manipulation, among others. The study also aims to determine the relationships between the family socioeconomic context and the predominant learning styles in relation to mathematics performance. The goal is to provide informed input for the design of pedagogical intervention strategies that contribute to strengthening those mathematical skills considered fundamental for academic success in secondary education.

3. Methods

3.1. Research Paradigm

For this research, a quantitative approach was used because, according to Blanco Jiménez et al. [5] this type of research offers the possibility of generalizing the results and facilitates control over the phenomenon to be studied. In the same vein, Behar Rivero [6] mentions that it allows for the treatment of concrete data in a sequential and probative manner. Following this line of thought, Hernández Sampieri et al. [1] describe that it uses data collection in order to test a hypothesis based on numerical measurement and statistical analysis, establishing patterns of behavior and testing theories.

Among some of the characteristics of this approach, we can highlight the following, according to Hernández Sampieri et al. [1]: it reflects the need to measure and estimate the magnitude of research phenomena or problems; data collection is based on measurement; data are the product of measurements, are represented by numbers (quantities), and must be analyzed using statistical methods; quantitative research should be as "objective" as possible; quantitative research attempts to generalize the results obtained from the sample of the universe or population, as well as to confirm and predict the phenomena investigated, seeking regularities and causal relationships between elements.

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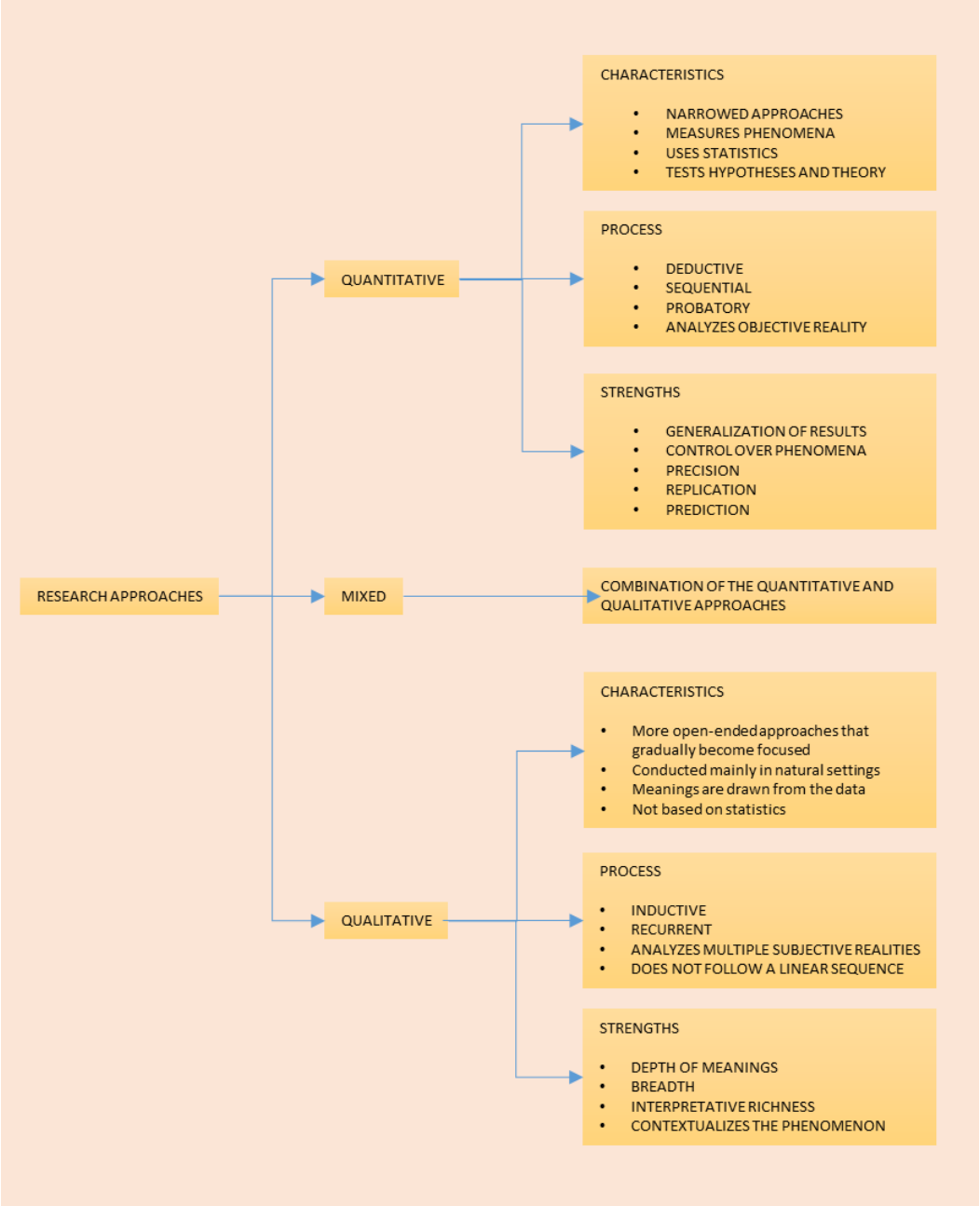

Figure 1.
Research Approach.
Source: Hernández Sampieri, et al. [1].

4. Research Level

The research design is non-experimental, as the variables to be studied are not deliberately manipulated. It is based on observing phenomena as they occur in their current context and then analyzing them. Therefore, no situation is constructed; rather, existing situations are observed. Although in non-experimental studies it is sometimes very difficult to separate the effects of the multiple variables involved in the study and to know how much each one contributed, in experimental

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studies the independent variables have less force than in reality, in contrast to non-experimental study variables, which are more real and consequently have greater validity [7].

The procedure described by Hernández Sampieri et al. [1] for non-experimental design, it consists of identifying one or more variables in a group of people, objects, situations, contexts, phenomena, communities, etc., and providing a description of them. This makes it possible to analyze how a phenomenon and its components are and how they manifest themselves, allowing the phenomenon to be detailed by measuring one or more of its attributes that describe the characteristics that identify the different elements and components, as well as their interrelationships [6].

This study is correlational because it aims to visualize how different phenomena relate or link to each other, or whether, on the contrary, there is no relationship between them. However, the main objective is to understand how a variable can behave by knowing the behavior of another related variable.

5. Measurement Instrument

According to Hernández Sampieri et al. [1] it is more appropriate to define measurement as "the process of linking abstract concepts with empirical indicators." They also point out that the measurement instrument is a resource used by the researcher to record information or data about the variables they have in mind. In this sense, for this research, two measurement instruments were generated, called "Diagnostic Evaluation: Learning Differential Calculus with ICT and Artificial Intelligence Tools" and "Survey for Parents," with 16 and 21 items, respectively, which aimed to evaluate dimensions such as: prior knowledge of differential calculus, educational background in mathematics, basic mathematical skills, use of technology for learning, access to and use of technology, perceptions of education during the pandemic, and attitudes towards the use of AI in education.

6. Procedure

In terms of data collection, the two previously designed measurement instruments were applied in a structured manner. This ensured the validity and reliability of the data. The diagnostic assessment was administered to students, and the survey to parents. Both instruments were administered via an online link, making them accessible to the population and ensuring the confidentiality of responses, which were automatically recorded in a database that protected and stored the information.

7. Participants

The population studied consisted of 301 students from CETis No. 167. For the application of the measurement instruments, a non-probabilistic, intentional sample was used, as it was not a random sample but was subject to relevance in terms of the objectives to be investigated, since it is directly proportional to the students involved in the teaching-learning process of differential calculus.

According to Hernández Sampieri et al. [1] determining an adequate sample in quantitative studies is essential, as it allows for the collection of representative information from the target population and, in turn, enables the generalization of results. In this sense, the number of participants is relevant, as it provides a solid basis for statistical analysis.

8. Results

After conducting the diagnostic evaluation of the students at CETIS 167, which is a secondary school located in the Milpa Alta municipality, 301 students were surveyed, of whom 173 were female and 128 were male, with 128 in the third semester and 173 in the sixth semester. The municipality of residence was also identified, revealing that 71.76% of the students live in Milpa Alta, 1.66% in Tláhuac, 25.24% in Xochimilco, and only 1.32% in other municipalities. The distribution by gender is shown in Table 1.

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Table 1.
Distribution of students according to their residence in municipalities.

Question	Gender	Milpa Alta	Xochimilco	Tlahuac	Other	Total
Which municipality do you live in?	Female	126	44	3	0	173
		41.86	14.61	1	0	57.48
	Male	90	32	2	4	128
		29.9	10.63	0.66	1.32	42.52
	Total	216	76	5	4	
		71.76	25.24	1.66	1.32	
Is your family originally from the town where you live?	Female	35	16	1	0	52
		11.62	5.31	0.33%	0	17.27
	Male	29	9	1	3	42
		9.63	2.99	0.33	1	13.95
	Total	64	25	2	3	94
		21.26	8.3	0.66	1	31.23

At the same time, the question was raised as to whether their families come from the same municipalities, where it was determined that 21.26% of the students come from Milpa Alta, 0.66% from Tláhuac, and 8.30% from Xochimilco. In other words, 52 female students and 42 male students come from these communities. Individuals who do not come from these communities come from other states of Oaxaca and Puebla. [2]. In other words, 31.23% of the students are considered to be from the communities of Milpa Alta, Xochimilco, and Tláhuac, among others.

Despite this, the economic activity of the relatives or guardians of the students surveyed was also taken into account, considering economic activities categorized as agriculture, commerce, industry, services, and tourism. According to Rodríguez Medina et al. [2] in 2018, 79.85% of farmers in the Milpa Alta region cultivated between 1,001 and 10,000 m², which implies small-scale production. Therefore, it can be seen that 10.30% of families are engaged in agriculture, 42.86% in the commercial sector, 6.31% in industry, 39.87% in services, and only 0.66% in tourism as their main economic activity. The data is distributed as follows, Table 2.

Table 2.
Data on economic activity and professional qualifications of family members.

Question	Gender		B	C	D	E	Total
What is your family's economic activity?	Women's	13	80	5	74	1	173
A) Agricultural		4.32	26.58	1.66	24.58	0.33	57.48
B) Commercial	Male	18	49	14	46	1	128
C) Industry		5.98	16.28	4.65	15.28	0.33	42.52
D) Services	Total	31	129	19	120	2	
E) Tourism		10.3	42.86	6.31	39.87	0.66	
How many family members do you have who hold a professional degree?	Female	72	42	28	22	9	
A) None		23.92%	13.95	9.3	7.31	2.99	
B) One	Male	49	22	23	25	9	
C) Two		16.28	7.31	7.64	8.31	2.99	
D) Three to five	Total	121	64	51	47	18	
E) More than 6		40.2	21.26	16.94	15.61	5.98	

It is questioned whether the professional level of their tutors and family members has an impact. To this end, students were asked how many members of their family had a degree or professional training, and it was determined that 40.20% of students have no family members with professional training. In total, 21.26% of students have only one relative with professional training, while 16.94% have two relatives with professional qualifications. Those with three, four, or five relatives with professional

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training represent 15.61% of the total. Only 5.98% of students have more than six relatives with professional training.

Despite the number of individuals who selected agriculture as their family's economic activity, this is not reflected in the total, as several family members are involved in or support agricultural tasks. Therefore, many people with professional training continue to support their families as a second job without direct financial remuneration [2]. This contrasts with the use of land in Milpa Alta for agricultural activities, whether in irrigated agriculture, located to the north of the municipality, or in seasonal agriculture of semi-permanent crops, located near the municipality and better known as Villa Milpa Alta. Similarly, there is a large area of forest, located mainly to the south of the municipality. The municipality of Milpa Alta is located to the south of Mexico City, together with the municipalities of Xochimilco and Tláhuac, as shown in Figure 1a. Most of its surface area is covered by forests or is perceived as a rural area. This municipality mainly produces alfalfa, vegetables, corn, potatoes, beans, peas, carrots, nopal, and other products.

Figure 1a.
Location of Milpa Alta, in Mexico City.
Source: Rodríguez Gamiño et al. [8].

CETIS 167 is located in the town of San Salvador Cuauhtenco, as shown in Figure 1b. It can be seen that it is on the border with the Xochimilco municipality (purple circle). Many families in these areas are considered community members and, as previously mentioned, own large areas of land. Given that younger generations do not show much interest in rural activities, the commercialization of land for housing has been promoted, gradually increasing the urban area. Over time, informal settlements and agricultural areas have been integrated. However, families who choose to move to this municipality

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gradually incorporate patron saint celebrations as part of their cultural customs.

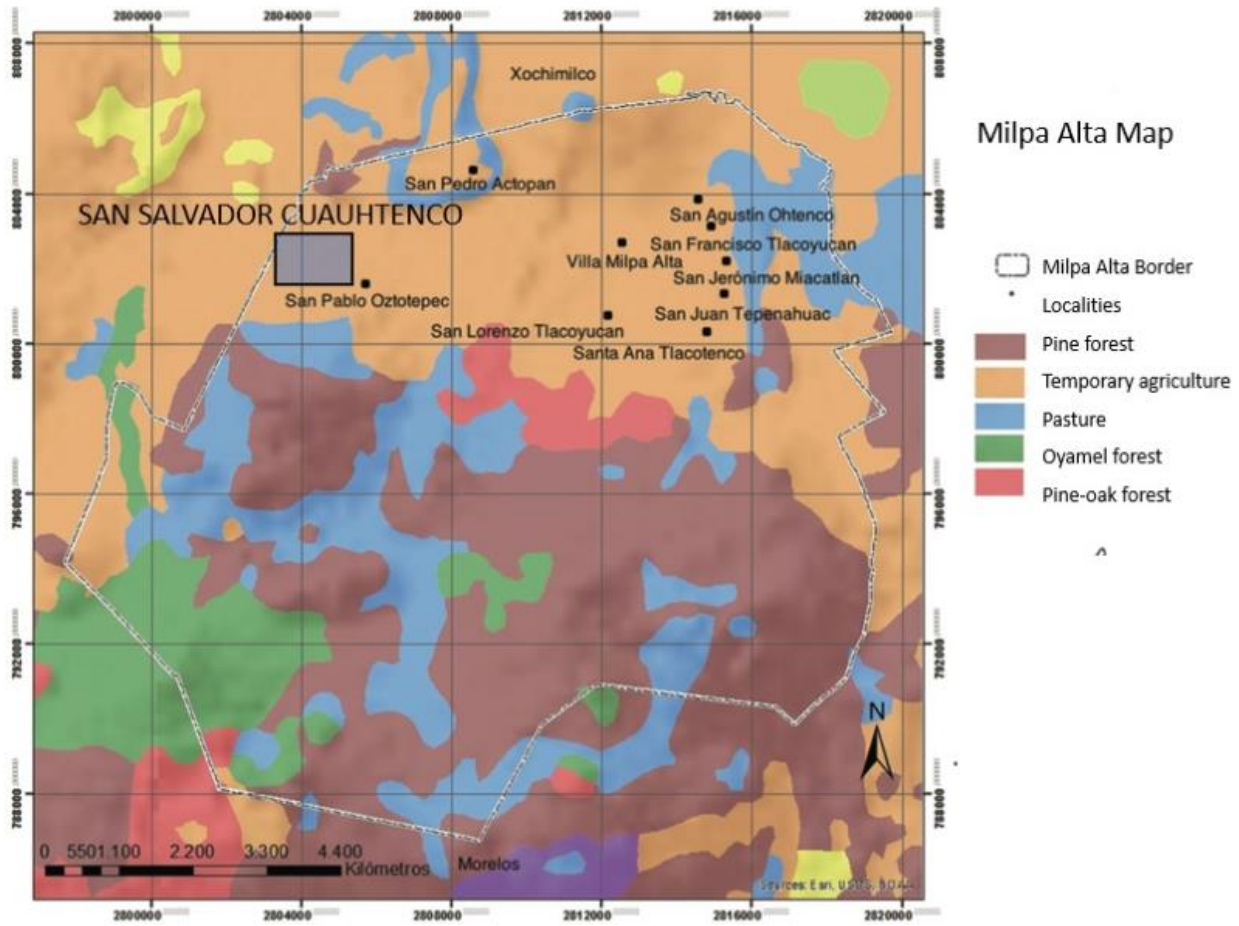

Figure 1b.
Location of the town of San Salvador.
Source: Rodríguez Gamiño et al. [8].

The economic activity carried out by parents or guardians who do not have a bachelor's degree was analyzed. Of these, 5.32% work in the agricultural sector, 16.28% in the commercial sector, 1.99% in industry, 16.28% in services, and 0.33% in the tourism sector. Additionally, when determining the municipality in which they reside, it was found that 29.9% of the students are from Milpa Alta, and their relatives do not have a professional degree. This contrasts with 9.96% of the Xochimilco region, who also do not have a professional degree. This accounts for 39.86% of the families of the survey participants. See Table 3.

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Table 3.
Data on family members who do not have a bachelor's degree, categorized by economic activity and municipality.

Family members who do not have a bachelor's degree					
	Agricultural	**Commercial**	**Industry**	**Services**	**Tourism**
Women	7 2.33	33 10.96	0	32 10.63	0
Male	9 2.99	16 5.32	6 1.99	17 5.65	1 0.33
Total	*16* *5.32*	*49* *16.28*	*6* *1.99*	*49* *16.28*	*1* *0.33*
	Milpa Alta	**Xochimilco**	**Other**		
Female	*52* *17.27*	*20* *6.64*	*0* *0*		
Male	*38* *12.62*	*10* *3.32*	*1* *0.33*		
Total	*90* *29.9*	*30* *9.96*	*1* *0.33*		

It was also necessary to determine their career or academic aspirations upon completing upper secondary education. In summary, 60.79% of students chose to continue their studies at a higher level or in a different specialization than the one they are pursuing at CETIS 167. 23.25% chose to start a business. For 13.62%, the choice of wanting to work after completing upper secondary education is relevant. And only 2.32% chose to join the family business. See Table 4.

Table 4.
Medium-term expectations for CETIS 167 students.

Job Expectations of Students				
	Continue studies	**Start a business**	**Work**	**Join the business**
Female	114 37.87	36 11.96	21 6.97	2 0.66
Male	69 22.92	34 11.29	2 6.64	5 1.66
Total	*183* *60.79*	*70* *23.25*	*41* *13.62*	*7* *2.32*

Despite the alternatives chosen in the previous question, students were asked which profession or field they would like to specialize in. It was found that 55.45% of students still do not know or do not recognize the area in which the university degree they want to pursue after completing secondary education is located.

For Art and Design Sciences (CapD), 5.98% of students chose this option; for Communication Sciences and Design (CCD), 4.98% of students chose this option; for Medical and Biological Sciences (CMB), 8.97% of students chose this option; for Social and Administrative Sciences (CSA), 8.63%; for Humanities and Arts, 3.32%; for Engineering (ICFM), 8.97% chose this field, and 3.65% of students chose not to answer. The distribution is shown in Table 5 below.

Table 5.
Measurement model reliability test.

Selection of higher education programmes								
	CApD	**CCD**	**CMB**	**CSA**	**HyA**	**ICFM**	**Did not respond**	**Other**
Female	13 4.31	9 2.99	2 6.97	18 5.98	6 1.99	10 3.32	7 2.32	89 29.56
Male	5 1.66	6 1.99	6 1.99	8 2.65	4 1.32	17 5.64	4 1.32	78 25.91
Total	*18* *5.98*	*15* *4.98*	*27* *8.97*	*26* *8.63*	*10* *3.32*	*27* *8.97*	*11* *3.65*	*167* *55.48*

It is noticeable that most students are interested in Medical and Biological Sciences (MBS), while men show interest in engineering. When examining the professions they wish to pursue after completing secondary education, it is noticeable that some show interest in careers such as Food Preparation, Law, and Medicine, which corroborates the above. Among the most common options are law, administration, medicine, military or police, veterinary medicine, nursing, gastronomy, education, and various engineering fields.

The study and diagnostic questions focused on identifying the delays caused by the COVID-19 pandemic in arithmetic and algebra. The pandemic phase, or period of virtual lessons, lasted from April 2020 to 7 June 2021. Although some schools resumed classes partially during February to May 2021 [9, 10]. Students currently in the second and third years of upper secondary education had the opportunity to attend secondary school classes during the pandemic period. The subjects covered at this level include the fundamentals of arithmetic and algebra, with a view to continuing with more sophisticated mathematical processes.

The objective was to recognize the circumstances that arose during the pandemic period in Mexico and how they affected academic performance. Therefore, the question was raised as to whether synchronous classes in mathematics were recorded on any digital medium during that period. During the pandemic, 67.44% of students indicated that they had mathematics classes. However, 21.59% of survey participants indicated that they did not attend and did not know if classes were held during that period. See Table 6.

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Table 6.
Measurement model reliability test…

Be honest in answering this question. During primary, secondary, and upper secondary school, in mathematics class,	**Gender**	**Sometimes**	**FALSE**	**TRUE**
I had classes via videoconference (Meet, Google, Zoom, and similar platforms).	Female	17	29	127
		5.65	9.63	42.19
	Male	16	36	76
		5.32	11.96	25.25
	Total	33	65	203
		10.96	21.59	67.44
Due to a lack of services, only photocopying and/or reading activities were carried out.	Female	35	77	61
		11.63	25.58	20.27
	Male	19	65	44
		6.31	21.59	14.62
	Total	54	142	105
		17.94	47.18	34.88
I couldn't attend classes or submit assignments, yet I still passed.	Male	5	126	42
		1.66	41.86	13.95
	Male	9	85	34
		2.99	28.24	11.3
		14	211	76
	Total	4.65	70.1	25.25
Despite the efforts of previous teachers, I find it difficult to understand mathematics.	Male	34	47	92
		11.3	15.61	30.56
	Male	20	47	61
		6.64	15.61	20.27
	Total	54	94	153
		17.94	31.23	50.83

The second question corroborates the previous statement: 34.88% of students believe that they only received copies and/or readings to be able to attend math class. Only 47.18% refute this statement, affirming that they had online lessons, but some thought that they used copies of activities on occasion during class. See Table 6.

It is important to note that during the 2020-2021 academic year, students were not allowed to fail due to circumstances related to the pandemic, in addition to the fact that lessons had to be conducted virtually. Furthermore, the minimum grade for students was 6, with the president stating that all students who had or had not taken part in remote classes should be credited [3]. It was not until November 2022 that the 5 to 10 grading scale was reconsidered, where 5 meant failure and 6 to 10 meant passing [11].

Although two-thirds of the students surveyed attended virtual classes, one-third claimed that they did not attend classes but were credited. Some students considered dropping out of school during the pandemic, as they felt they could not acquire the necessary knowledge to continue their professional education. They therefore returned to school when the pandemic ended and face-to-face teaching resumed. It is estimated that, nationwide, 520,000 students dropped out of primary and secondary school [12].

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This whole scenario and its consequences are not unique to the pandemic but are intrinsic to the current education system. As can be seen, 50.83% of students say they do not understand mathematics, mainly algebra and arithmetic. Some of the difficulties raised are that students only think about passing subjects without reflecting on or understanding the topics covered. Other comments made are due to the fact that teachers have an excessive administrative workload and do not focus on tasks related to the subjects.

Although the teachers carried out their tasks by teaching lessons synchronously in front of a group, and assignments were provided to pass the course, it was decided to set certain challenges to identify areas of opportunity for the students. An attempt was made to determine whether they understood and used the hierarchy of arithmetic operations, which is the essential foundation for handling numbers. To this end, a double-entry question was used to select the steps in an organized manner. It can be seen that grouping signs, such as parentheses, square brackets, or curly brackets, were chosen by 56.14% of the students. The rest selected the first step incorrectly. Table 7 shows the results.

When carrying out the analysis to determine whether the students understood the hierarchy of operations, a filter was applied. During the first analysis, 95 women and 74 men participated. During the second hierarchy, the number dropped to 66 women and 57 men. In step three, it decreased slightly to 57 women and 52 men. Finally, it was determined that 57 men and 47 women were familiar with the steps of the operation hierarchy. This equates to 34.55% of the students, which is just under a third of the survey participants.

After extensive filtering, where students who correctly understood the hierarchy of operations were selected, they were compared with students who knew the clearing hierarchy. According to CONAMAT [13] and Baldor [14] in the hierarchy of operations, addition and/or subtraction are performed first, followed by multiplication and/or division, and finally powers and/or roots are addressed. This sequence is relevant for solving first-degree equations. Considering this, among students who know the hierarchy of operations, 15 women and 7 men only know that the first step to solve an equation is to add and/or subtract. Only 12 women and 7 men understand the continuation involving multiplication and/or roots; and finally, only 10 women and 7 men understand that solving first-degree equations is completed with powers and/or roots. Refer to Table 7.

Table 7.
Measurement model reliability test.

	Gender	Grouping signs	Powers and/or roots	Multiplication and/or division	Addition and/or subtraction
Hierarchy of operations →	Female	95	66	57	57
		31.56	21.93	18.94	18.94
	Male	74	57	52	47
		24.58	18.94	17.28	15.61
	Total	169	123	109	104
		56.15	40.86	36.21	34.55
Clearance hierarchy ←	Women		10	12	15
			3.32	3.99	4.98
	Male		7	7	7
			2.33	2.33%	2.33
	Total		17	19	22
			5.65	6.31	7.31

Arithmetic manipulation was identified by studying the responses to arithmetic operations. In the first operation, 52.49% of all students chose the correct answer, which was to perform the division first

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and then the addition. Another group of 37.20% of students chose the alternative in which they first performed the addition and then the division, obtaining the result 20.28. Of the rest, there is no method to justify the wrong answer. See Table 8.

The following operation involves a power and a root. To do this, following the hierarchy of operations, the power is solved first and then the addition is performed. 82.05% of the students selected the correct answer of 40 units. Those who chose 400 argued that the numbers 15 and 5 were added first, and then the power was calculated. The students who chose the option 150 argued that the number 5 was multiplied by 2 and then multiplied by 15, resulting in 150. The other answer is unfounded.

The third question refers to recognizing the use of signs and grouping signs in an arithmetic operation. Of the total, only 55.14% answered correctly. In the alternatives cited, they justified their answer by removing parentheses, transforming it into addition and subtraction, or by multiplying the first number twice, i.e., five by three and five by five, and then adding.

In the final question, which only involves a change of sign and addition, 55.14% of students answered correctly. For the answer -48, they argue that 12 is divided by 4 and then the signs are multiplied three times. Twenty-three point twenty-five percent of the people selected this answer. The answer -16 follows a procedure very similar to the one mentioned previously, that is, the numbers 12 and 4 are added, and then the signs are multiplied. In answer number 8, the sum is calculated considering the existence of positive and negative signs, and then these signs are multiplied.

Table 8.
Measurement model reliability test.

Question	**Gender**	**A**	**B**	**C**	**D**
Solve the following operation: 100+42/7?	Female	62	13	10	88
					29.24
A) 20.28	Male	50	5	3	70
B) 21					23.26
C) 10	Total	112	18	13	158
D) 106					52.49
Solve the following operation: 5^2+15?	Female	139	5	19	10
		46.18			
A) 4	Male	108	4	14	2
B) 1		35.88			
C) 150	Total	247	9	33	12
D) 4		82.06			
Solve the following operation: 5⌈3(35/7)⌉?	Female	21	34	21	97
					32.23
A) 2	Male	16	27	16	69
B) 5+15+5=15					22.92
C) 5+3+5=15	Total	37	61	37	166
D) 7					55.15
Solve the operation (12-(-4))?	Female	44	11	27	91
					30.23
A) -48	Male	26	8	19	75
B) -16					24.92
C) 8	Total	70	19	46	166
D) 1					55.15

In addition, a comparison was made of the students who answered the hierarchy of operations correctly, determining which answers they selected correctly in the arithmetic operations. Of the 34.55% who selected the hierarchy of operations correctly, only 22.59% answered the first problem correctly, with a result of 106 units. For the second arithmetic problem, it was noted that the answer of 40 units is 21.28%. In the third problem involving multiplication and division with grouping signs, the

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proportion of students decreases to 14.95%. A total of 9.9% of students solved all four problems correctly. See Table 9.

Table 9.
Measurement model reliability test.

Arithmetic exercises					
Answers	**Hierarchy of operations**	**1**	**40**	**75**	**16**
Female	57	38	35	25	17
	18.94	12.62	11.68	8.31	5.65
Male	47	30	29	20	13
	15.61	9.97	9.63	6.64	4.32
Total	104	68	64	45	30
	34.55	22.59	21.26	14.95	9.97

Students who were able to properly answer the hierarchy of operations were also compared, identifying whether their responses were chosen adequately in the arithmetical operations. With 106 units, only 34.55% answered the first item correctly in the hierarchy of operations formed by 22.59% of these. Regarding the second arithmetic problem, the response rate was 21.28% for 40 units. In the third problem, which involved multiplication and division with parentheses, the percentage of students decreased to 14.95%. A total of 9.9% of students solved all four problems correctly. See Table 9.

It is noteworthy that only 9.97% of respondents are familiar with the hierarchy of operations and manipulation. Carpenter et al. [4] describe relational thinking as the act of paying attention to the set of numerical structural relationships that are embedded in numerical expressions. This principle involves using numerical properties to modify mathematical expressions, rather than simply calculating numerically and providing an answer. Among the possible reasons that emerged during the pandemic are the stages from 2020 to 2022, when students were in secondary education and even at the beginning of upper secondary education.

They may have experienced feelings of sadness, fatigue, decreased concentration, and energy levels, which led to the interruption of their studies, social isolation, and predictions of an economic crisis [15].

Another factor that has impacted students' mental health is the high levels of stress associated with academic demands and managing virtual learning at home, contrasted with the limited strategies developed to assist them during the lockdown period [16]. This could be the result of the number of cases reported in the vicinity of the town of San Salvador Cuauhtenco, as well as in the municipalities of Milpa Alta, San Antonio Tecomitl, and San Pablo Oztotepec [17, 18].

According to COVID-19 data, 40,357 individuals with the disease and 1,960 suspected cases were recorded out of a total population of approximately 153,000. This is equivalent to 27% of the municipality's inhabitants. According to the data, the highest peaks in the number of infected people occurred in 2022 [19, 20]. See Figure 2.

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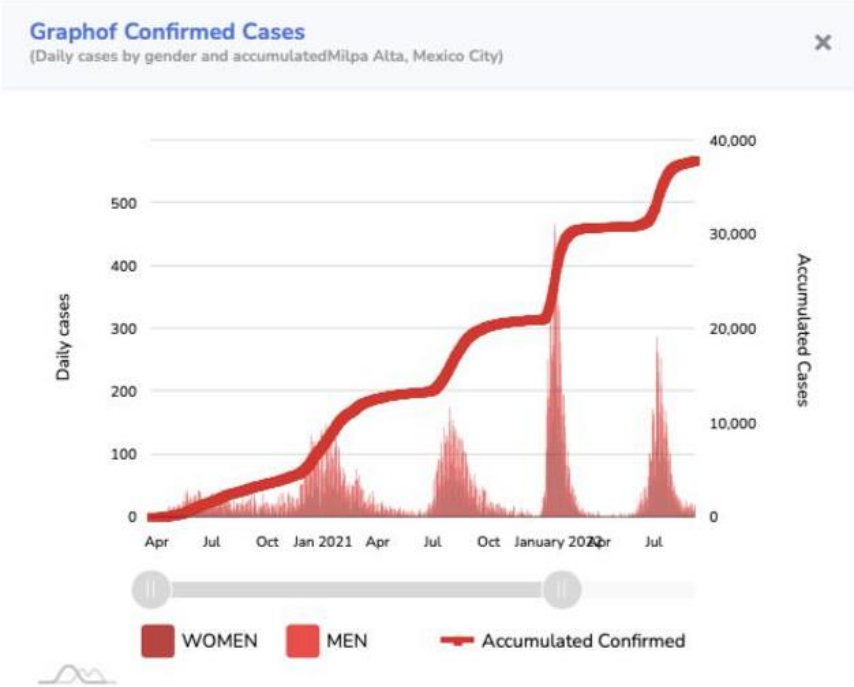

Figure 2.
Data for the period compared to the number of COVID-19 cases.
Source: CONAHCYT [19].

In addition, the lack of mathematical concepts, incomplete or missing procedures, and inconsistency in following instructions, among other factors, are considered. In addition to the factors mentioned above, another possible reason identified is the inability to read and understand mathematical statements, along with several complaints from teachers and students, thus complicating the study. Given that learning mathematics requires abstract thinking and the ability to reason in symbolic terms, the context, activities, tasks, discourse, and shapers of this knowledge must be taken into account at each educational level. To this end, reflection is essential [21, 22].

The Honey Alonso test information was studied to determine the types of learning. Figure 3 shows that reflective learning has a higher average than the other three, with a value of 15.83, as well as a lower standard deviation. The theoretical learning style ranks second, with an average of 15.23 and a standard deviation of 2.93. In third place is pragmatic learning, and finally, active learning. Solano Ocampos et al. [23] point out that the reflective learning style suggests that a student is meticulous, thoroughly examining information before reaching a conclusion.

Thus, this type of student benefits from debates, surveys, feedback, and interviews. Second, students with a theoretical learning style were examined. These students tend to be extremely perfectionist due to their objectivity and critical thinking. Tasks that promote their learning include model building, statistics, background research and investigation, and the application of theories. Thirdly, there is pragmatic learning, which is distinguished by enthusiasm for applying ideas. To use this learning method, case studies should be carried out, problems solved, debates held, and reflection on how to implement concepts [24, 25].

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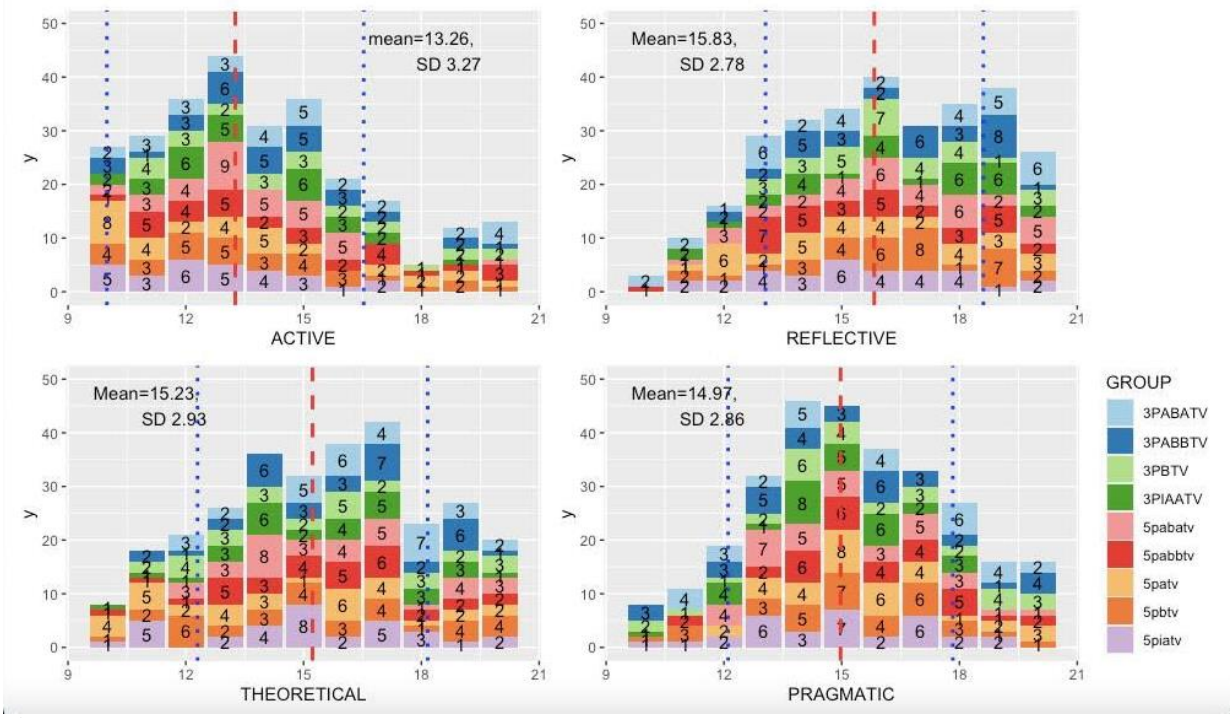

Figure 3.
Honey Alonso test for learning styles, a) active, b) reflective, c) theoretical, and d) pragmatic.

Experts in mathematics education propose examining and seriously addressing students' errors, discussing their misconceptions with them, and presenting them with mathematical scenarios that enable them to correct their thinking [26]. As Solís Pollorena and Ramírez-Noriega [27] points out, students do not acquire knowledge due to a known factor, such as insufficient methodology, inadequate teacher training, an adverse environment, depression or lack of concentration, among other factors. In other words, students possess the cognitive skills; it would only be necessary to modify the topics and restructure the sequence of tasks. In addition, it is also necessary for students to set aside time to review and do repetition exercises, not just to study, in order to acquire fundamental knowledge.

According to the study, the generic skills that promote the strengthening of algebra are cognitive skills, focused on the ability to abstract, analyze, and synthesize information. Furthermore, it is possible to apply knowledge in practice; arithmetic exercises and even basic algebra can be carried out with academic activities in real contexts. Similarly, progress in reading and writing artistic, technical, and scientific texts contributes to the development of students' verbal and written communication [25].

9. Conclusion

Although students have varied learning abilities and can visit different entities or individuals to clarify their questions, in the subject of algebra and arithmetic, this skill has not been adequately developed, as it has been observed that almost no students go to the library to look for resources to manage the processes. Currently, they have opted to use digital media to achieve the result. In addition, they have sought to discover a simple method that does not require much reasoning in order to take advantage of it. It would be appropriate to look for educational methods or sequences that encourage research and questioning in order to properly manage the hierarchy of operations and the hierarchy of clearing, which are seen as the essential foundation of mathematics. Of course, this does not rule out all the theories that make up academic education itself.

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At the same time, there is no learning method that is totally effective, but a combination of pragmatic, reflective, and active methods could be considered. Perhaps the drawback is also the result of the way the algebra problems are formulated, as well as the wrong way of requesting the necessary information in the exercise itself. It was also noted that the incorrect resolution of the exercises is the result of overly informal use by the trainer and a lack of mathematical evidence for their proper manipulation. For future work and to reduce the algebraic arithmetic progress, it is suggested that texts be developed that solve problems with real contexts. As practical examples, using modeling that is not only theoretical but also manipulable in educational facilities.

Not forgetting adequate feedback and reinforcement exercises, for which it is essential to repeat the concepts during the resolution process.

10. Future Lines of Research

Investigate the design, application, and results obtained by mathematics teaching methodologies that emphasize the rural context and economic activities typical of Milpa Alta: agriculture, commerce, and services. These methodologies serve as tools for teaching arithmetic and algebraic concepts. Include the impact on conceptual understanding and long-term retention of mathematical concepts.

Conduct a longitudinal analysis of the psychosocial impact of the pandemic on mathematical academic performance. In this regard, we propose to develop a medium- and long-term follow-up study to analyze the evolution of mathematical skills in students impacted by virtual education during the pandemic. This will enable an analysis of academic resilience factors, learning recovery strategies, and the identification of predictors of success in higher education.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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